Keweenaw Bay Indian Community
Tribal Water Quality Report under Section 305 (b), Clean Water Act

Submitted to:
U.S. EPA Region 5
Water Division
77 West Jackson Boulevard
Chicago, IL 60604

Prepared by:
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For the
Keweenaw Bay Indian Community
Natural Resources Department
January, 2005

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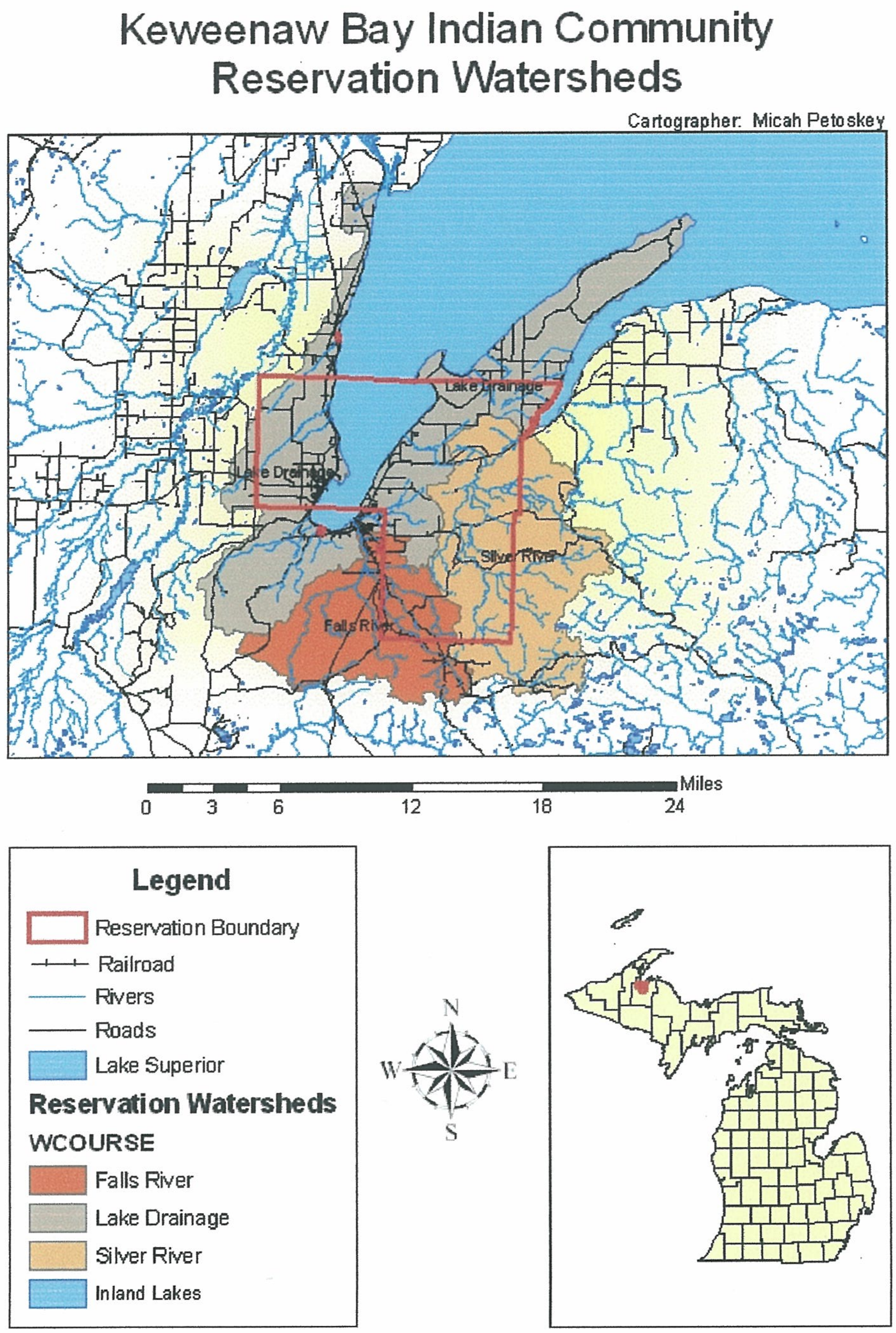
Introduction

The Keweenaw Bay Indian Community (KBIC) Water Program has developed and implemented a comprehensive monitoring program to assess the health of Reservation lakes, rivers and streams, and has developed a management plan for wetlands. The Clean Water Act establishes a process in §305(b) by which States and Tribes prepare a report describing the status of surface and ground water quality in their jurisdiction. This is the first report that details the current quality of the KBIC Reservation waters. Although KBIC does not yet have federally approved water quality standards, the application process is already underway and a draft set of standards have been completed. The U.S. Environmental Protection Agency (EPA) compiles the data from these reports, summarizes them, and transmits this information to Congress as a nationwide analysis of water quality. This 305(b) process is the principal means by which KBIC can evaluate whether the quality of Reservation waters meet KBIC water quality standards, the progress made in maintaining and/or restoring water quality, and the presence of any problems.

Figure 1



Keweenaw Bay Indian Community
Reservation Watersheds
Cartographer: Micah Petoskey
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Lake Drainage
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Background

KBIC is located in Baraga County in the northwestern part of Michigan's Upper Peninsula, near the southern terminus of Keweenaw Bay (Figure 1). The L'Anse Reservation consists of 70,327 contiguous acres which includes approximately 17 miles of Lake Superior shoreline, 80 miles of streams and rivers, 15,000 acres of lakes and 3000 acres of wetlands (Table 1a). The Reservation borders the nearby village of L'Anse and encompasses the village of Baraga. KBIC has concentrated housing units in Baraga, Zeba (a community 3 miles northeast of L'Anse), and the Township of Chocolay in Marquette County. KBIC's Reservation boundaries were established by Treaty on September 30, 1854.

KBIC currently has 3,076 enrolled members, a large percentage that lives within the L'Anse Reservation boundaries. The Tribe employs approximately 1000 people within Tribal government and other Tribally-owned enterprises. The terrain within the boundaries of the L'Anse Reservation is generally hilly with steep slopes rising away from the Keweenaw Bay shore. Elevation ranges from 183 m at Keweenaw Bay to about 550 m in the most southeastern section of the Reservation.

KBIC is highly concerned about the quality and protection of its environment. In a calendar year 2000 survey conducted for the KBIC Integrated Resources Management Plan which was adopted by the Tribal Council in 2003, water quality was the number one concern among Tribal members. A strong cultural relationship between the Ojibwa people and their land has resulted in spiritual, medicinal, hunting, gathering and fishing traditions that are adversely impacted by activities that adversely impact the environment. The Tribe wishes to ensure a high quality environment for the Community by avoiding or mitigating activities that are potentially detrimental to the land and water resources, Tribal members, and KBIC culture.

As a result of this commitment to the protection of natural resources, KBIC established the Keweenaw Bay Natural Resources Department. More recently, the KBIC Tribal Council established a Natural Resources Committee as part of the Keweenaw Bay Indian Conservation District. The mission of this Committee, and of the Tribal Council, is to assist in the development and implementation of the resource management plans of the Natural Resources Department. Both of these actions demonstrate the Community's recognition of the need to protect and manage its natural resources.

To this end, KBIC developed and adopted a 10 year Integrated Resource Management Plan (IRMP) with established objectives and benchmarks, including water quality, to improve the long term protection and management of natural resources for the Community.

Table 1-Atlas Table (Inventory of Tribal Water Resources)

Factor/Resource	Value
Reservation population (residents)	3,076

Reservation surface area (acres)	70,327
Total miles of rivers and streams	~80
Miles of intermittent (non-perennial) streams (subset)	~49
Number of sampling points on rivers or streams	17
Number of inland lakes/reservoirs/ponds	164
Acres of inland lakes/reservoirs/ponds	~259
Acres of Lake Superior	~15,000
Number of sampling points on inland lakes/reservoirs/ponds	5
Number of sampling points on Coastal Waters/Great Lakes	3
Acres of wetlands	~3,000

The Villages of L'Anse and Baraga and KBIC own and operate an individual public water supply system. All three of these systems obtain and treat water from Keweenaw Bay of Lake Superior.

In addition, surface water is also an important economic, recreational and ecological resource. Commercial and recreational fishing, recreational boating, and swimming are significant human activities dependent on surface waters in the area. Area lakes, wetlands, streams and rivers also serve as critical nursery habitat for a number of fish, waterfowl and wildlife species in the region. KBIC maintains several wild rice lakes/impoundments both inland and on Keweenaw Bay.

KBIC Surface Water Monitoring Program

A continuous surface water quality monitoring program is crucial to assure future water quality of Reservation waters for generations to come. KBIC monitoring has established a baseline water quality database for the current state of the L'Anse Reservation surface waters. This database may be used as a basis to issue future NPDES permits and used as a reference by future water quality studies to determine changes in water quality over time. Monitoring will allow for the identification and characterization of impaired or pristine waters.

Annual monitoring also serves to track any trends or changes in water quality and the effectiveness of management practices intended to remediate impaired waters.

KBIC implemented its water quality monitoring strategy in 2001, with a four year baseline data collection effort completed in 2004, to be followed by our ongoing modified core monitoring program beginning in 2005. The strategy includes sampling physical, chemical and biological parameters on selected water bodies throughout the L'Anse Indian Reservation. Our surface water quality monitoring is conducted using field and laboratory standard operating procedures presented in the KBIC Surface Water Quality Monitoring, Quality Assurance Project Plan (QAPP), approved by US EPA. Additional data used to develop this report comes from associated monitoring projects, including surface water organics monitoring and watershed inventories, both of which were conducted following US EPA approved QAPP's.

The current KBIC Surface Water Monitoring Program is described by the EPA approved Quality Assurance plan, including the overall lake and stream monitoring strategy, data quality objectives, and the field and lab SOP's that are followed. Wild rice lakes are sampled yearly for physical parameters, nutrient and contaminant analysis. Sulfate is also measured in the water column in order to evaluate against the wild rice water quality criterion (<10mg/liter). The following parameters are included in our monitoring program:

1. Total Phosphorus (TP)
2. Total Phosphorus, Reactive
3. Total Kjeldahl Nitrogen (TKN)
4. Nitrite + Nitrate
5. Ammonia Nitrogen
6. Total Suspended Solids
7. Total Dissolved Solids
8. Chloride
9. Calcium
10. Potassium
11. Silica, dissolved reactive
12. Magnesium, total
13. Semi annual toxic metals analysis: Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury
14. Alkalinity as $CaCO_3$
15. Total Hardness
16. Chlorophyll (a) in select lakes and Keweenaw Bay, Lake Superior
17. Coliform, Fecal (MFFCC)
18. Depth profile of: temperature, dissolved oxygen, pH, specific conductance
19. Secchi transparency
20. Sulfide
21. Sulfate (in wild rice lakes)
22. Chlorinated Herbicides in select water bodies.

Fish community and macro invertebrate data are added as available from Tribal Fisheries. Physical habitat assessments are conducted semi annually at all monitoring sites.

Monitoring sites are located on all significant Reservation water bodies, excluding intermittent streams and isolated, small wetlands. The sampling scheme is on a semi-rotational basis with larger stream systems and lakes having either multiple sampling points, and/or being sampled in every year of the baseline data collection. Smaller systems and lakes are sampled at a single station, for at least two of the four years. Yearly analysis is conducted monthly for four months, from May through August. Metals analysis occurs twice yearly, in the first and last sampling months.

Impacts on Reservation Water Bodies

Current development trends have the potential or have been observed to adversely impact the waters of the Reservation. These trends include 8 new commercial leases, 59 new home leases and 27 cabin leases from 2001-2003. KBIC continues to allow the harvest of logs on their land at a rate of ~ 200 acres/ year and private logging interests vary from ~ 500 - 2,000 acres/ year. At present, there has been a noticeable increase in the number of new home starts on the Reservation. The lack of environmental health ordinances which require such things as; a specific setback from the water's edge, correction of failing septic systems, isolation distances for wells and septic systems, combined with an overall increase in the number of homes along water resources have the potential to increase runoff, erosion and the input of nutrients to our waters. While environmental health ordinances are not currently in effect, a Utility Ordinance adopted in January of 2002 is a first step in reducing the human impacts to Reservation waters. KBIC is currently working on developing a Land Use Management Plan, which will include the development of environmental and health codes and ordinances.

In addition to development trends, current and previous logging practices have adversely impacted areas within many watersheds on the Reservation. The sedimentation load for many streams has increased due to poorly constructed stream crossings and logging roads. Sedimentation adversely impacts critical habitat of macro invertebrate species and spawning areas for native fish. All aquatic species are important for a sustainable ecological community and for recreational and cultural uses among Tribal members on the Reservation.

Lastly, recent metallic sulfide mineral exploration activity within the Reservation and ceded territory underscores the need for continued and enhanced monitoring of the quality of KBIC water resources. Metallic sulfide mining represents the single largest potential threat to reservation and surrounding water quality.

Lakes Assessment

KBIC has assessed four Reservation lakes based on pollution concentrations (Nutrients), D.O., (Dissolved Oxygen) and Secchi Depth (Table 2a). All four lakes exceeded at least one threshold value, either Total phosphorus, or Total Kjeldahl Nitrogen. Although all inland lakes are supporting their designated uses (Table 2d), nutrient loading from farming and residential development is considered one of the three, key pollutants (Tables 2f, 2g). Three of the four lakes assessed also exhibit some measure of habitat degradation noted during physical assessments and/or biologic community impairment, noted during biologic assessments such as macro invertebrate surveys (Table 2e). Two of the lakes noted as supporting their designated uses have not been assessed for water quality, habitat, or biologic assemblages. Contamination of fish tissues and metals loading from contaminated sediments (mine tailings) have been noted as concerns for Keweenaw Bay, Lake Superior (Tables 2e, 2f, 2g).

Table 2a - Water Quality Conditions in Inland Lake Systems

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant/Measure	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for Secchi and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Secchi Depth (meters) (SD)	-	-	< 2	-
Chlorophyll-a (ug/l) (Chl)	-	-	> 7	-
Dissolved Oxygen (mg/l) (DO)	7.3545	3.23	< 5	
Total Phosphorous (ug/l) (TP)	15.55	36	>27	1
Total Kjeldahl Nitrogen (mg/l) (TKN)	0.441	0.83	> .5	3

Table 2b - Trophic State[1] of Reservation Inland Lakes

TSI[2]	Chl (ug/L)	SD (m)	TP (ug/L)	Definition of Trophic State	No. of Lakes in this Category	Lake Acres in this Category
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	0	0
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallower lakes may become anoxic	3	-
40-50	2.6-7.3	4-2	12-24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer	2	-
50-60	7.3-20	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	-	-
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	-	-

70-80	56-155	0.25-0.5	96-192	Hypereutrophy: (light- limited productivity). Dense algae and macrophytes	-	-
>80	>155	<0.25	192-384	Algal scums, few macrophytes	-	-
Sufficient Data not Available to Assess					159	-

[1] Trophic state refers to the total weight of living biological material (biomass) in a water body at a specific location and time. Time and location-specific measurements can be aggregated to produce water body-level estimations of trophic state.

[2] Carlson's Trophic State Index (TSI) (1977) uses algal biomass as the basis for trophic state classification. Three variables, chlorophyll pigments, Secchi depth, and total phosphorus, independently estimate algal biomass. The range of the index is from approximately zero to 100, although the index theoretically has no lower or upper bounds.

Table 2c - Water Quality Conditions in Coastal Waters/Great Lakes Sampling Points

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for SD and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**
Chl (ug/l)	-	-	> 7	-
D.O. (mg/l)	8.37	5.74	< 5	0
TP (ug/l)	8	8	>27	0
TKN (mg/l)	0.1465	0.16	> .5	0

Table 2d - Individual Use Support Summary - Lake Systems

Type of Water body: Lake Systems, Including Lake Superior			
Use	**Number of Lakes Supporting**	**Number of Lakes Not Supporting**	**Number of Lakes Not Assessed**
Aquatic life	6	0	158
Recreation	6	0	158

Type of Water body: Lake Systems, Including Lake Superior			
Ceremonial/Tribally defined use(s)	6	0	158

Table 2e - Other Water Quality Concerns in Lake Systems

Concern	Number of Lakes Where Concern Noted	Lake Acres Where Concern Noted
Habitat Degradation	2	-
Impairments noted in Biological Communities (diversity and/or abundance)	1	-
Contamination in Fish Tissues	1	~15,000 (Lake Superior)

Table 2f - Key Pollutants and Stressors in Lake Systems

Three Most Significant Causes of Water Quality Degradation - Lake Systems (Pollutants and Stressors)	
Pollutant/Stressor	**Number of Lakes Affected by this Stressor**
1. Sediments	2
2. Metals	3, including Keweenaw Bay
3. Nutrient Loading	4

Table 2g - Sources of Water Quality Degradation in Lake Systems

Three Most Significant Sources of Water Quality Degradation - Lake Systems	
Sources of Pollutant Loadings	**Number of Lakes Affected by these Sources**
1. Contaminated Sediments	(Keweenaw Bay)
2 Dam Failure (clean sediments)	2
3. Residential/Rural Development (Nutrients)	4

Rivers and Streams Assessment

KBIC has assessed 18 Reservation Rivers and Streams, based on pollutant concentrations and dissolved oxygen content. Nutrient loading found in Reservation lakes is also found to be concern for Reservation rivers and streams. Nine rivers, or streams exceeded the threshold value for Total Kjeldahl Nitrogen, eight exceeded the Total Phosphorus threshold (Table 3a). (Table 3d) notes nutrient loading as one of the three, key pollutants/stressors in fluvial systems on the Reservation. The Three most significant sources of pollution for Reservation fluvial systems all contribute to the nutrient loading noted within the KBIC Reservation (Table 3e). KBIC has assessed three rivers, or streams that are not currently supporting two of their designated uses, recreation and Tribal/ceremonial (Table 3b). This is a direct result of nutrient loading and bacterial contamination due to residential/rural development and animal wastes. Habitat degradation and biologic community impairments (Table 3c) are mainly due to sediment loading/stream bank modification and canopy reduction associated with forestry management practices.

Table 3a- Water Quality Conditions in Rivers and Streams

Mean and Maximum Values - Pollutant Concentrations/Measurements in Rivers and Streams				
Pollutant	**Mean Concentration / Measurement**	**Maximum Concentration Measured (Min. for D.O)**	**Threshold Value**	**Number of Sampling Points Where Threshold Value Exceeded**
D.O. (mg/l)	8.045294	4.03	<5	3
Total Suspended Solids (mg/l) (TSS)	3.897059	28	> 10	3
Chloride (mg/l)	10.03125	84	> 50 *	2
TP (ug/l)	41.912	270	> 30	8
TKN (mg/l)	.470809	1.80	> .5	9

* Threshold based on KBIC draft Water Quality Standards for waters designated as a public water supply source, OR connected to Keweenaw Bay.

Table 3b. Individual Use Support Summary - Rivers and Streams

Type of Water body: Rivers and Streams (in Stream miles)			
Use	**Number of Streams Supporting**	**Number of Streams Not Supporting**	**Number of Streams Not Assessed**
Aquatic life	18	0	unknown
Recreation	15	3	unknown
Ceremonial/Tribally defined use(s)	15	3	unknown

Table 3c - Other Water Quality Concerns in Rivers and Streams

Concern	Number of Streams Where Concern Noted
Habitat Degradation	7

Impairments noted in Biological Communities (diversity and/or abundance)	2
Contamination in Fish Tissues	-

Table 3d - Key Pollutants and Stressors in Rivers and Streams

Three Most Significant Causes of Water Quality Degradation - River/Stream Systems (Pollutants and Stressors)
Pollutant/Stressor
1. Clean Sediment loading/stream bank modification
2. Canopy Reduction
3. Nutrient Loading/Bacteria

Table 3e - Sources of Water Quality Degradation in Rivers and Streams

Three Most Significant Sources of Water Quality Degradation - Rivers and Streams
Sources of Pollutant Loadings
1. Forestry/Land Use
2 Residential/industrial Development
3. Animal Wastes

Table 4a - Source Water Protection

KBIC members living on or near the L'Anse Indian Reservation are serviced by three, public water supplies. Two are Tribally owned and have US EPA approved Source Water Assessment and Protection plans (SWAPP's). The third public water supply owned and operated by the Village of Baraga has an approved Source Water Assessment.

Source Water Assessment and Protection	
Number of Tribal Community Public Water Systems	2
Number of Tribal Community Public Water Systems for Which Source Water Assessment and Protection Plans have been Completed	2
Number of Tribal Community Public Water Systems Where Assessments were Completed and the Sources Are Susceptible to Contamination	2

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Prepared by:
Micah Petoskey, Water Resources Specialist
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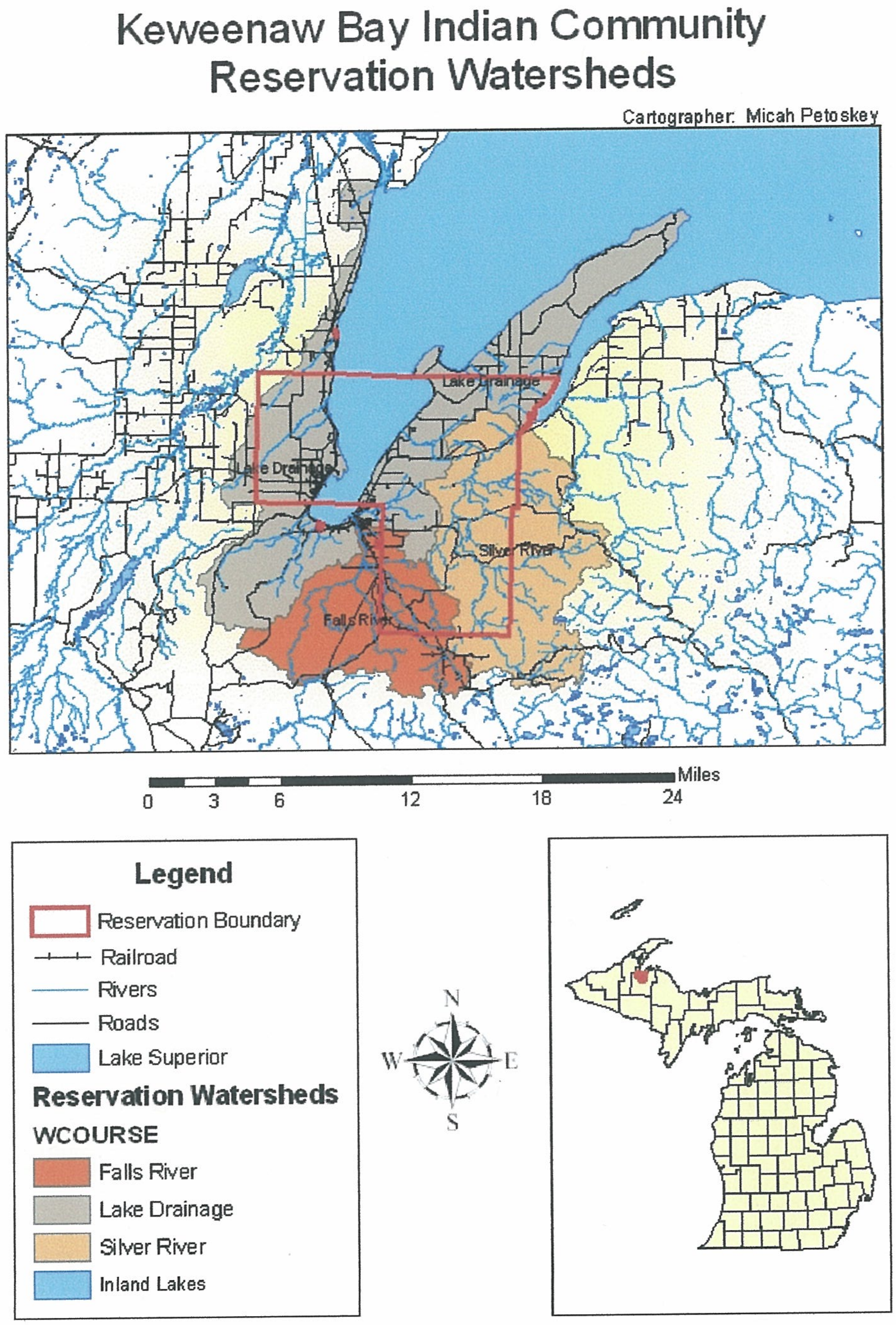
Figure 1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3. Total Kjeldahl Nitrogen (TKN)
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5. Ammonia Nitrogen
6. Total Suspended Solids
7. Total Dissolved Solids
8. Chloride
9. Calcium
10. Potassium
11. Silica, dissolved reactive
12. Magnesium, total
13. Toxic metals analysis: Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury
14. Alkalinity as $CaCO_3$
15. Total Hardness
16. Coliform, Fecal (MFFCC)
17. Depth profile of: temperature, dissolved oxygen, pH, specific conductance
18. Secchi transparency
19. Sulfide
20. Sulfate (in wild rice lakes)

Fish community and macro invertebrate data are added from previous years as available from Tribal Fisheries. As of FY2008 macro invertebrate data will be collected annually by the water department. Physical habitat assessments are conducted semi annually at all monitoring sites.

Monitoring sites are located on all significant Reservation water bodies, excluding intermittent streams and isolated, small wetlands. The sampling scheme is on a semi-rotational basis with larger stream systems and lakes having either multiple sampling points, and/or being sampled in every year of data collection. Smaller systems and lakes are sampled at a single station, rotated every other year.

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Lastly, recent metallic sulfide mineral exploration activity within the Reservation and ceded territory underscores the need for continued and enhanced monitoring of the quality of KBIC water resources. Metallic sulfide mining represents the single largest potential threat to reservation and surrounding water quality.

Lakes Assessment

KBIC has assessed four Reservation lakes based on pollution concentrations (Nutrients), D.O., (Dissolved Oxygen) and Secchi Depth (Table 2a). All four lakes exceeded at least one threshold value, either Total phosphorus, or Total Kjeldahl Nitrogen. Although all inland lakes are supporting their designated uses (Table 2d), nutrient loading from farming and residential development is considered one of the three, key pollutants (Tables 2f, 2g). Three of the four lakes assessed also exhibit some measure of habitat degradation noted during physical assessments and/or biologic community impairment, noted during biologic assessments such as macro invertebrate surveys (Table 2e). Two of the lakes noted as supporting their designated uses have not been assessed for water quality, habitat, or biologic assemblages. Contamination of fish tissues and metals loading from contaminated sediments (mine tailings) have been noted as concerns for Keweenaw Bay, Lake Superior (Tables 2e, 2f, 2g).

Table 2a - Water Quality Conditions in Inland Lake Systems

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant/Measure	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for Secchi and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Secchi Depth (meters) (SD)	-	-	< 2	-
Chlorophyll-a (ug/l) (Chl)	-	-	> 7	-
Dissolved Oxygen (mg/l) (DO)	7.4683	3.65	< 5	
Total Phosphorous (ug/l) (TP)	16.15	39	>27	1
Total Kjeldahl Nitrogen (mg/l) (TKN)	0.651	0.97	> .5	3

Table 2b - Trophic State[1] of Reservation Inland Lakes

TSI[2]	Chl (ug/L)	SD (m)	TP (ug/L)	Definition of Trophic State	No. of Lakes in this Category	Lake Acres in this Category
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	0	0
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallower lakes may become anoxic	3	-
40-50	2.6-7.3	4-2	12-24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer	2	-
50-60	7.3-20	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	-	-
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	-	-

70-80	56-155	0.25-0.5	96-192	Hypereutrophy: (light- limited productivity). Dense algae and macrophytes	-	-
>80	>155	<0.25	192-384	Algal scums, few macrophytes	-	-
Sufficient Data not Available to Assess					159	-

[1] Trophic state refers to the total weight of living biological material (biomass) in a water body at a specific location and time. Time and location-specific measurements can be aggregated to produce water body-level estimations of trophic state.

[2] Carlson's Trophic State Index (TSI) (1977) uses algal biomass as the basis for trophic state classification. Three variables, chlorophyll pigments, Secchi depth, and total phosphorus, independently estimate algal biomass. The range of the index is from approximately zero to 100, although the index theoretically has no lower or upper bounds.

Table 2c - Water Quality Conditions in Coastal Waters/Great Lakes Sampling Points

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for SD and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**
Chl (ug/l)	-	-	> 7	-
D.O. (mg/l)	8.42	5.89	< 5	0
TP (ug/l)	9	9	>27	0
TKN (mg/l)	0.2316	0.19	> .5	0

Table 2d - Individual Use Support Summary - Lake Systems

Type of Water body: Lake Systems, Including Lake Superior			
Use	**Number of Lakes Supporting**	**Number of Lakes Not Supporting**	**Number of Lakes Not Assessed**
Aquatic life	6	0	158
Recreation	6	0	158

Type of Water body: Lake Systems, Including Lake Superior			
Ceremonial/Tribally defined use(s)	6	0	158

Table 2e - Other Water Quality Concerns in Lake Systems

Concern	Number of Lakes Where Concern Noted	Lake Acres Where Concern Noted
Habitat Degradation	2	-
Impairments noted in Biological Communities (diversity and/or abundance)	1	-
Contamination in Fish Tissues	1	~15,000 (Lake Superior)

Table 2f - Key Pollutants and Stressors in Lake Systems

Three Most Significant Causes of Water Quality Degradation - Lake Systems (Pollutants and Stressors)	
Pollutant/Stressor	**Number of Lakes Affected by this Stressor**
1. Sediments	2
2. Metals	3, including Keweenaw Bay
3. Nutrient Loading	4

Table 2g - Sources of Water Quality Degradation in Lake Systems

Three Most Significant Sources of Water Quality Degradation - Lake Systems	
Sources of Pollutant Loadings	**Number of Lakes Affected by these Sources**
1. Contaminated Sediments	(Keweenaw Bay)
2 Dam Failure (clean sediments)	2
3. Residential/Rural Development (Nutrients)	4

Rivers and Streams Assessment

KBIC has assessed 18 Reservation Rivers and Streams, based on pollutant concentrations and dissolved oxygen content. Nutrient loading found in Reservation lakes is also found to be concern for Reservation rivers and streams. Nine rivers, or streams exceeded the threshold value for Total Kjeldahl Nitrogen, eight exceeded the Total Phosphorus threshold (Table 3a). (Table 3d) notes nutrient loading as one of the three, key pollutants/stressors in fluvial systems on the Reservation. The Three most significant sources of pollution for Reservation fluvial systems all contribute to the nutrient loading noted within the KBIC Reservation (Table 3e). KBIC has assessed three rivers, or streams that are not currently supporting two of their designated uses, recreation and Tribal/ceremonial (Table 3b). This is a direct result of nutrient loading and bacterial contamination due to residential/rural development and animal wastes. Habitat degradation and biologic community impairments (Table 3c) are mainly due to sediment loading/stream bank modification and canopy reduction associated with forestry management practices.

Table 3a- Water Quality Conditions in Rivers and Streams

Mean and Maximum Values - Pollutant Concentrations/Measurements in Rivers and Streams				
Pollutant	**Mean Concentration / Measurement**	**Maximum Concentration Measured (Min. for D.O)**	**Threshold Value**	**Number of Sampling Points Where Threshold Value Exceeded**
D.O. (mg/l)	8.21563	4.16	<5	3
Total Suspended Solids (mg/l) (TSS)	3.91723	29	> 10	3
Chloride (mg/l)	10.2196	88	> 50 *	2
TP (ug/l)	41.621	289	> 30	8
TKN (mg/l)	.486351	1.70	> .5	9

* Threshold based on KBIC draft Water Quality Standards for waters designated as a public water supply source, OR connected to Keweenaw Bay.

Table 3b. Individual Use Support Summary - Rivers and Streams

Type of Water body: Rivers and Streams (in Stream miles)			
Use	**Number of Streams Supporting**	**Number of Streams Not Supporting**	**Number of Streams Not Assessed**
Aquatic life	18	0	unknown
Recreation	15	3	unknown
Ceremonial/Tribally defined use(s)	15	3	unknown

Table 3c - Other Water Quality Concerns in Rivers and Streams

Concern	Number of Streams Where Concern Noted
Habitat Degradation	7

Impairments noted in Biological Communities (diversity and/or abundance)	2
Contamination in Fish Tissues	-

Table 3d - Key Pollutants and Stressors in Rivers and Streams

Three Most Significant Causes of Water Quality Degradation - River/Stream Systems (Pollutants and Stressors)
Pollutant/Stressor
1. Clean Sediment loading/stream bank modification
2. Canopy Reduction
3. Nutrient Loading/Bacteria

Table 3e - Sources of Water Quality Degradation in Rivers and Streams

Three Most Significant Sources of Water Quality Degradation - Rivers and Streams
Sources of Pollutant Loadings
1. Forestry/Land Use
2 Residential/industrial Development
3. Animal Wastes

Table 4a - Source Water Protection

KBIC members living on or near the L'Anse Indian Reservation are serviced by three, public water supplies. Two are Tribally owned and have US EPA approved Source Water Assessment and Protection plans (SWAPP's). The third public water supply owned and operated by the Village of Baraga has an approved Source Water Assessment.

Source Water Assessment and Protection	
Number of Tribal Community Public Water Systems	2
Number of Tribal Community Public Water Systems for Which Source Water Assessment and Protection Plans have been Completed	2
Number of Tribal Community Public Water Systems Where Assessments were Completed and the Sources Are Susceptible to Contamination	2

Keweenaw Bay Indian Community

Tribal Water Quality Report under Section 305 (b), Clean Water Act

Submitted to:
U.S. EPA Region 5
Water Division
77 West Jackson Boulevard
Chicago, IL 60604

Prepared by:
Micah Petoskey, Water Resources Specialist
For the
Keweenaw Bay Indian Community
Natural Resources Department
March, 2010

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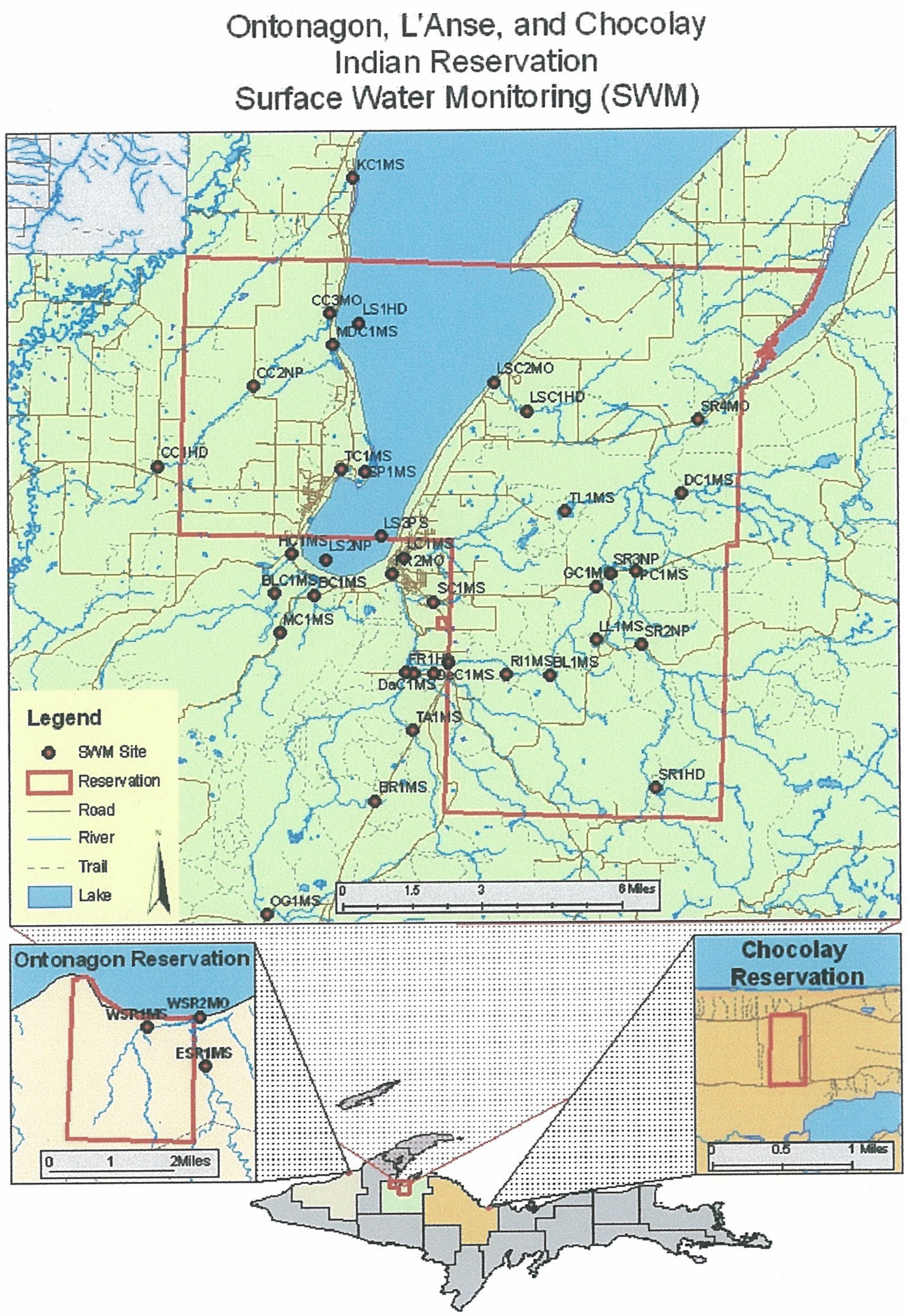
Introduction

The following is a comprehensive description of the water quality in and around the Keweenaw Bay Indian Community as part of our monitoring program. Our study encompasses both the L'Anse and Ontonagon Reservations. We have provided a description of the background of KBIC as well as a physical description of the area. This includes our surface water monitoring program and an assessment of the data we have collected during this grant cycle.

The potential impacts to reservation waters are touched on later in the report. They include residential and commercial construction, logging, a lack of environmental health ordinances and the potential for sulfide mining. The singular impact of each of these potential impactors is overshadowed by the cumulative impact that all would have on the Reservation.

The Keweenaw Bay Indian Community (KBIC) Water Program has developed and implemented a comprehensive monitoring program to assess the health of Reservation lakes, rivers and streams, and has developed a management plan for wetlands. The Clean Water Act establishes a process in §305(b) by which States and Tribes prepare a report describing the status of surface and ground water quality in their jurisdiction. Although KBIC does not yet have federally approved water quality standards, the application process is already underway and a draft set of standards have been completed. The U.S. Environmental Protection Agency (EPA) compiles the data from these reports, summarizes them, and transmits this information to Congress as a nationwide analysis of water quality. This 305(b) process is the principal means by which KBIC can evaluate whether the quality of Reservation waters meet KBIC water quality standards, the progress made in maintaining and/or restoring water quality, and the presence of any problems.

Figure 1


Ontonagon, L'Anse, and Chocolay
Indian Reservation
Surface Water Monitoring (SWM)
KC1MS
CC3MO
LS1HD
MDC1MS
CC2NP
LSC2MO
LSC1HD
SR4MO
CC1HD
TC1MS
SP1MS
DC1MS
TL1MS
LS3PS
HC1MS
LS2NP
BLC1MS
BC1MS
SC1MS
GC1MS
SR3NP
PC1MS
MC1MS
LL1MS
SR2NP
FR1HD
RI1MS
BL1MS
DaC1MS
TA1MS
SR1HD
BR1MS
OG1MS
Legend
SWM Site
Reservation
Road
River
Trail
Lake
0
1.5
3
6 Miles
Ontonagon Reservation
WSR1MS
WSR2MO
ESR1MS
0
1
2Miles
Chocolay
Reservation
0
0.5
1 Miles

Background

KBIC is located in Baraga County in the northwestern part of Michigan's Upper Peninsula, near the southern terminus of Keweenaw Bay (Figure 1). The L'Anse Reservation consists of 70,327 contiguous acres which includes approximately 17 miles of Lake Superior shoreline, 80 miles of streams and rivers, 15,000 acres of lakes and 3000 acres of wetlands (Table 1a). The Reservation borders the nearby village of L'Anse and encompasses the village of Baraga. KBIC has concentrated housing units in Baraga, Zeba (a community 3 miles northeast of L'Anse), and the Township of Chocolay in Marquette County. KBIC's Reservation boundaries were established by Treaty on September 30, 1854.

KBIC currently has 3,076 enrolled members, a large percentage that lives within the L'Anse Reservation boundaries. The Tribe employs approximately 1000 people within Tribal government and other Tribally-owned enterprises. The terrain within the boundaries of the L'Anse Reservation is generally hilly with steep slopes rising away from the Keweenaw Bay shore. Elevation ranges from 183 m at Keweenaw Bay to about 550 m in the most southeastern section of the Reservation.

KBIC is highly concerned about the quality and protection of its environment. In a calendar year 2000 survey conducted for the KBIC Integrated Resources Management Plan which was adopted by the Tribal Council in 2003, water quality was the number one concern among Tribal members. A strong cultural relationship between the Ojibwa people and their land has resulted in spiritual, medicinal, hunting, gathering and fishing traditions that are adversely impacted by activities that adversely impact the environment. The Tribe wishes to ensure a high quality environment for the Community by avoiding or mitigating activities that are potentially detrimental to the land and water resources, Tribal members, and KBIC culture.

As a result of this commitment to the protection of natural resources, KBIC established the Keweenaw Bay Natural Resources Department. More recently, the KBIC Tribal Council established a Natural Resources Committee as part of the Keweenaw Bay Indian Conservation District. The mission of this Committee, and of the Tribal Council, is to assist in the development and implementation of the resource management plans of the Natural Resources Department. Both of these actions demonstrate the Community's recognition of the need to protect and manage its natural resources.

To this end, KBIC developed and adopted a 10 year Integrated Resource Management Plan (IRMP) with established objectives and benchmarks, including water quality, to improve the long term protection and management of natural resources for the Community.

Table 1-Atlas Table (Inventory of Tribal Water Resources)

Factor/Resource	Value
Reservation population (residents)	3,076
Reservation surface area (acres)	70,327

Total miles of rivers and streams	~80
Miles of intermittent (non-perennial) streams (subset)	~49
Number of sampling points on rivers or streams	33
Number of inland lakes/reservoirs/ponds	164
Acres of inland lakes/reservoirs/ponds	~259
Acres of Lake Superior	~15,000
Number of sampling points on inland lakes/reservoirs/ponds	7
Number of sampling points on Coastal Waters/Great Lakes	3
Acres of wetlands	~3,000

The Villages of L'Anse and Baraga and KBIC own and operate an individual public water supply system. All three of these systems obtain and treat water from Keweenaw Bay of Lake Superior.

In addition, surface water is also an important economic, recreational and ecological resource. Commercial and recreational fishing, recreational boating, and swimming are significant human activities dependent on surface waters in the area. Area lakes, wetlands, streams and rivers also serve as critical nursery habitat for a number of fish, waterfowl and wildlife species in the region. KBIC maintains several wild rice lakes/impoundments both inland and on Keweenaw Bay.

KBIC Surface Water Monitoring Program

A continuous surface water quality monitoring program is crucial to assure future water quality of Reservation waters for generations to come. KBIC monitoring has established a baseline water quality database for the current state of the L'Anse Reservation surface waters. This database may be used as a basis to issue future NPDES permits and used as a reference by future water quality studies to determine changes in water quality over time. Monitoring will allow for the identification and characterization of impaired or pristine waters.

Annual monitoring also serves to track any trends or changes in water quality and the effectiveness of management practices intended to remediate impaired waters.

KBIC implemented its water quality monitoring strategy in 2001, with a four year baseline data collection effort completed in 2004, to be followed by our ongoing modified core monitoring program which began in 2005. The strategy includes sampling physical, chemical and biological parameters on selected water bodies throughout the L'Anse Indian Reservation. Our surface water quality monitoring is conducted using field and laboratory standard operating procedures presented in the KBIC Surface Water Quality Monitoring, Quality Assurance Project Plan (QAPP), approved by US EPA. Additional data used to develop this report comes from associated monitoring projects, including surface water organics monitoring and watershed inventories, both of which were conducted following US EPA approved QAPP's.

The current KBIC Surface Water Monitoring Program is described by the EPA approved Quality Assurance plan, including the overall lake and stream monitoring strategy, data quality objectives, and the field and lab SOP's that are followed. Wild rice lakes are sampled yearly for physical parameters, nutrient and contaminant analysis. Sulfate is also measured in the water column in order to evaluate against the wild rice water quality criterion (<10mg/liter). The following parameters are included in our monitoring program:

1. Total Phosphorus (TP)
2. Total Phosphorus, Reactive
3. Total Kjeldahl Nitrogen (TKN)
4. Nitrite + Nitrate
5. Ammonia Nitrogen
6. Total Suspended Solids
7. Total Dissolved Solids
8. Chloride
9. Calcium
10. Potassium
11. Silica, dissolved reactive
12. Magnesium, total
13. Toxic metals analysis: Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury
14. Alkalinity as $CaCO_3$
15. Total Hardness
16. Coliform, Fecal (MFFCC)
17. Depth profile of: temperature, dissolved oxygen, pH, specific conductance
18. Secchi transparency
19. Sulfide
20. Sulfate (in wild rice lakes)

Fish community and macro invertebrate data are added from previous years as available from Tribal Fisheries. As of FY2008 macro invertebrate data will be collected annually by the water department. Physical habitat assessments using the GLEAS 51 are conducted semi annually at all monitoring sites.

Monitoring sites are located on all significant Reservation water bodies, excluding intermittent streams and isolated, small wetlands. The sampling scheme is on a semi-rotational basis with larger stream systems and lakes having either multiple sampling points, and/or being sampled in every year of data collection. Smaller systems and lakes are sampled at a single station, rotated every other year.

Impacts on Reservation Water Bodies

Current development trends have the potential or have been observed to adversely impact the waters of the Reservation. These trends include 8 new commercial leases, 59 new home leases and 27 cabin leases from 2001-2003. KBIC continues to allow the harvest of logs on their land at a rate of ~ 200 acres/ year and private logging interests vary from ~ 500 - 2,000 acres/ year. The lack of environmental health ordinances which require such things as; a specific setback from the water's edge, correction of failing septic systems, isolation distances for wells and septic systems, combined with an overall increase in the number of homes along water resources have the potential to increase runoff, erosion and the input of nutrients to our waters. While environmental health ordinances are not currently in effect, a Utility Ordinance adopted in January of 2002 is a first step in reducing the human impacts to Reservation waters. KBIC is currently working on developing a Land Use Management Plan, which will include the development of environmental and health codes and ordinances.

In addition to development trends, current and previous logging practices have adversely impacted areas within many watersheds on the Reservation. The sedimentation load for many streams has increased due to poorly constructed stream crossings and logging roads. Sedimentation adversely impacts critical habitat of macro invertebrate species and spawning areas for native fish. All aquatic species are important for a sustainable ecological community and for recreational and cultural uses among Tribal members on the Reservation.

Lastly, it has come to our attention that at least two companies are actively exploring areas within the Reservation as possible sites for metallic sulfide mines. Sulfide mining operations and the resulting wastes have the potential to severely and adversely impact the water resources and wildlife in the surrounding areas, within our counties and townships. The metallic sulfide mineral exploration activity within the Reservation and ceded territory underscores the need for continued and enhanced monitoring of the quality of KBIC water resources.

Lakes Assessment

KBIC has assessed four Reservation lakes based on pollution concentrations (Nutrients), D.O. (Dissolved Oxygen), and Secchi Depth (Table 2a). All four lakes exceeded at least one threshold value, either Total Phosphorus, or Total Kjeldahl Nitrogen. Although all inland lakes are supporting their designated uses (Table 2d), nutrient loading from farming and residential development is considered one of the three, key pollutants (Tables 2f, 2g). Three of the five lakes assessed also exhibit some measure of habitat degradation noted during physical assessments and/or biologic community impairment, noted during biologic assessments such as macro invertebrate surveys (Table 2e). Two of the lakes noted as supporting their designated uses have not been assessed for water quality, habitat, or biologic assemblages. Contamination of fish tissues and metals loading from contaminated sediments (mine tailings) has been noted as concerns for Keweenaw Bay, Lake Superior (Tables 2e, 2f, 2g).

Table 2a - Water Quality Conditions in Inland Lake Systems

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant/Measure	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for Secchi and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**
Secchi Depth (meters) (SD)	5.31	2.25	< 2	0
Chlorophyll-a (ug/l) (Chl)	-	-	> 7	-
Dissolved Oxygen (mg/l) (DO)	8.52	7.93	< 5	0

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Total Phosphorous (ug/l) (TP)	25.21	47	>27	1
Total Kjeldahl Nitrogen (mg/l) (TKN)	0.65	0.87	> .5	3

Table 2b - Trophic State of Reservation Inland Lakes

TSI [2]	Chl (ug/L)	SD (m)	TP (ug/L)	Definition of Trophic State	No. of Lakes in this Category	Lake Acres in this Category
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	0	0
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallower lakes may become anoxic	3	-
40-50	2.6-7.3	4-2	12-24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer	2	-
50-60	7.3-20	2-1	24-48	Eutrophy: Anoxic hypolimnia, macrophyte problems possible	-	-
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	-	-
70-80	56-155	0.25- 0.5	96-192	Hypereutrophy: (light- limited productivity). Dense algae and macrophytes	-	-

>80	>155	<0.25	192-384	Algal scums, few macrophytes	-	-
Sufficient Data not Available to Assess					159	-

[1] Trophic state refers to the total weight of living biological material (biomass) in a water body at a specific location and time. Time and location-specific measurements can be aggregated to produce water body-level estimations of trophic state.

[2] Carlson's Trophic State Index (TSI) (1977) uses algal biomass as the basis for trophic state classification. Three variables, chlorophyll pigments, Secchi depth, and total phosphorus, independently estimate algal biomass. The range of the index is from approximately zero to 100, although the index theoretically has no lower or upper bounds.

Table 2c - Water Quality Conditions in Coastal Waters/Great Lakes Sampling Points

Mean and Maximum Values - Pollutant Concentrations/Measurements in Lake Systems				
Pollutant	**Mean Concentration/ Measurement**	**Maximum Concentration (Minimum for SD and D.O.)**	**Threshold Value**	**Number of Lakes Where Threshold Value Exceeded**
Chl (ug/l)	-	-	> 7	-
D.O. (mg/l)	14.65	15.04	< 5	0
TP (ug/l)	3.70	4.11	>27	0
TKN (mg/l)	0.0822	0.0966	> .5	0

Table 2d - Individual Use Support Summary - Lake Systems

Type of Water body: Lake Systems, Including Lake Superior			
Use	**Number of Lakes Supporting**	**Number of Lakes Not Supporting**	**Number of Lakes Not Assessed**
Aquatic life	5	0	158
Recreation	5	0	158
Ceremonial/Tribally defined use(s)	5	0	158

Table 2e - Other Water Quality Concerns in Lake Systems

Concern	Number of Lakes Where Concern Noted	Lake Acres Where Concern Noted
Habitat Degradation	2	14
Impairments noted in Biological Communities (diversity and/or abundance)	1	6
Contamination in Fish Tissues	1	~15,000 (Lake Superior)

Table 2f - Key Pollutants and Stressors in Lake Systems

Three Most Significant Causes of Water Quality Degradation - Lake Systems (Pollutants and Stressors)	
Pollutant/Stressor	**Number of Lakes Affected by this Stressor**
1. Sediments	2
2. Metals	3, including Keweenaw Bay
3. Nutrient Loading	4

Table 2g - Sources of Water Quality Degradation in Lake Systems

Three Most Significant Sources of Water Quality Degradation - Lake Systems	
Sources of Pollutant Loadings	**Number of Lakes Affected by these Sources**
1. Contaminated Sediments	(Keweenaw Bay)
2 Dam Failure (clean sediments)	2
3. Residential/Rural Development (Nutrients)	4

Rivers and Streams Assessment

KBIC has assessed 18 Reservation Rivers and Streams, based on pollutant concentrations and dissolved oxygen content. Nutrient loading found in Reservation lakes is also found to be concern for Reservation rivers and streams. Nine rivers, or streams exceeded the threshold value for Total Kjeldahl Nitrogen, eight exceeded the Total Phosphorus threshold (Table 3a). (Table 3d) notes nutrient loading as one of the three, key pollutants/stressors in fluvial systems on the Reservation. The Three most significant sources of pollution for Reservation fluvial systems all contribute to the nutrient loading noted within the KBIC Reservation (Table 3e). KBIC has assessed three rivers, or streams that are not currently supporting two of their designated uses, recreation and Tribal/ceremonial (Table 3b). This is a direct result of nutrient loading and bacterial contamination due to residential/rural development and animal wastes. Habitat degradation and biologic community impairments

(Table 3c) are mainly due to sediment loading/stream bank modification and canopy reduction associated with forestry management practices.

Table 3a- Water Quality Conditions in Rivers and Streams

Mean and Maximum Values - Pollutant Concentrations/Measurements in Rivers and Streams				
Pollutant	**Mean Concentration / Measurement**	**Maximum Concentration Measured (Min. for D.O)**	**Threshold Value**	**Number of Sampling Points Where Threshold Value Exceeded**
D.O. (mg/l)	12.17063	6.144.16	<5	0
Total Suspended Solids (mg/l) (TSS)	3.675778	27.625	> 10	2
Chloride (mg/l)	8.2570	88	> 50 *	4
TP (ug/l)	38.247	368.5	> 30	8
TKN (mg/l)	1.279	74	> .5	9

* Threshold based on KBIC draft Water Quality Standards for waters designated as a public water supply source, OR connected to Keweenaw Bay.

Table 3b. Individual Use Support Summary - Rivers and Streams

Type of Water body: Rivers and Streams (in Stream miles)			
Use	**Number of Streams Supporting**	**Number of Streams Not Supporting**	**Number of Streams Not Assessed**
Aquatic life	18	0	unknown
Recreation	15	3	unknown
Ceremonial/Tribally defined use(s)	15	3	unknown

Table 3c - Other Water Quality Concerns in Rivers and Streams

Concern	Number of Streams Where Concern Noted
Habitat Degradation	8
Impairments noted in Biological Communities (diversity and/or abundance)	2
Contamination in Fish Tissues	-

Table 3d - Key Pollutants and Stressors in Rivers and Streams

Three Most Significant Causes of Water Quality Degradation - River/Stream Systems (Pollutants and Stressors)
Pollutant/Stressor
1. Clean Sediment loading/stream bank modification
2. Canopy Reduction
3. Nutrient Loading/Bacteria

Table 3e - Sources of Water Quality Degradation in Rivers and Streams

Three Most Significant Sources of Water Quality Degradation - Rivers and Streams
Sources of Pollutant Loadings
1. Forestry/Land Use
2 Residential/industrial Development
3. Animal Wastes

Table 4a - Source Water Protection

KBIC members living on or near the L'Anse Indian Reservation are serviced by three, public water supplies. Two, Kawbawgam and Zeba, are Tribally owned and have US EPA approved Source Water Assessment and Protection plans (SWAPP's). The third public water supply owned and operated by the Village of Baraga has an approved Source Water Assessment.

Source Water Assessment and Protection	
Number of Tribal Community Public Water Systems	2
Number of Tribal Community Public Water Systems for Which Source Water Assessment and Protection Plans have been Completed	2
Number of Tribal Community Public Water Systems Where Assessments were Completed and the Sources Are Susceptible to Contamination	2

USGS
science for a changing world

Water-Data Report 2010

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI

Southcentral Lake Superior Basin
Dead-Kelsey Subbasin

LOCATION.--Lat 46°45′04″, long 88°21′42″ referenced to North American Datum of 1927, in NW ¼ NW ¼ sec.7, T.50 N., R.32 W., Baraga County, MI, Hydrologic Unit 04020105, at Indian Road, 9.0 mi south of L'Anse.

DRAINAGE AREA.--3.5 mi^2, revised.

SURFACE-WATER RECORDS

PERIOD OF RECORD.--October 2007 to current year.

GAGE.--Water-stage recorder and crest-stage gage. Elevation of gage is 950 ft above sea level, from topographic map.

REMARKS.--Records good except for estimated daily discharges, which are fair. Gage-height telemeter at station.

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010
DAILY MEAN VALUES
[e, estimated]

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3.9	5.3	3.3	e1.8	e2.1	e1.6	7.4	5.2	1.4	1.6	1.5	1.0
2	2.9	4.7	3.1	e1.8	e2.1	e1.6	6.5	3.9	1.3	1.3	1.6	1.3
3	4.1	4.7	2.9	e1.8	e2.0	e1.7	5.8	3.2	1.3	1.1	1.4	3.3
4	5.4	4.7	2.9	e1.8	e1.8	e1.7	5.6	3.0	1.7	1.1	1.3	3.2
5	6.0	4.8	2.8	e1.8	e1.7	e1.8	5.2	3.4	1.8	1.3	1.1	2.0
6	8.1	4.4	e2.3	e1.8	e1.7	2.5	4.7	3.2	1.7	2.1	1.0	1.6
7	15	4.2	2.7	2.0	e1.6	e3.0	4.4	3.1	1.5	2.7	1.00	2.1
8	7.0	4.0	2.5	2.0	e1.6	4.0	4.3	5.3	1.7	7.7	1.0	2.0
9	4.6	3.6	e2.3	2.0	e1.6	e4.9	4.4	6.1	3.2	3.1	1.0	1.6
10	3.5	3.3	e2.2	e1.8	1.9	e5.6	4.4	5.9	2.5	1.8	0.95	1.4
11	3.0	3.2	e2.2	2.0	1.8	e7.2	4.0	4.7	3.4	1.7	0.97	2.0
12	2.8	2.9	e2.2	2.0	e1.6	e9.0	3.6	3.8	4.3	2.1	0.94	2.1
13	2.7	2.8	e2.2	2.0	e1.6	e10	3.5	3.7	3.1	1.6	1.1	1.6
14	2.6	2.7	e2.2	2.0	e1.7	e9.5	3.4	4.1	2.4	1.6	0.99	1.3
15	2.6	2.8	e2.2	2.0	e1.7	e8.9	4.0	3.7	2.1	1.9	1.7	1.8
16	2.4	2.7	e2.2	2.1	e1.8	e8.4	4.0	3.1	2.7	1.3	1.7	5.6
17	2.2	2.6	e2.2	2.2	e1.8	e8.2	3.6	2.7	2.1	1.2	1.1	3.2
18	2.2	2.4	2.7	2.3	e1.7	e12	3.3	2.5	1.6	1.2	1.2	2.3
19	2.3	2.6	2.6	2.2	e1.7	e9.6	3.2	2.3	1.6	1.2	2.1	1.8
20	2.4	2.9	2.5	e2.3	e1.7	e5.7	3.1	2.1	1.3	1.2	5.0	1.5
21	5.9	2.7	2.4	e2.4	e1.7	e4.9	3.0	2.1	1.5	1.1	3.9	1.5
22	13	2.5	2.3	e2.5	2.0	e7.3	3.0	2.0	2.9	1.1	2.2	1.4
23	14	2.6	e1.9	e2.4	1.8	8.2	2.9	1.9	2.1	1.1	1.6	4.4
24	33	2.6	e2.0	2.5	1.8	7.9	2.8	1.8	1.7	1.1	1.3	37
25	19	2.7	e2.1	e2.4	e1.6	7.3	2.8	1.6	2.0	1.0	1.2	12
26	12	5.5	e2.1	e2.4	e1.6	e6.6	2.7	1.5	2.9	0.96	1.1	6.2
27	9.8	5.2	e2.1	e2.4	e1.6	5.9	2.6	1.4	4.6	0.95	1.1	3.8
28	7.4	4.0	e2.1	e2.4	e1.6	6.3	2.6	1.4	8.5	1.2	1.0	2.7
29	6.0	3.6	e2.0	e2.3	---	6.1	2.6	1.3	3.5	0.97	0.89	2.4
30	6.4	3.4	e1.9	e2.2	---	6.1	3.3	1.3	2.2	1.1	0.86	2.5
31	5.9	---	e1.9	e2.1	---	7.7	---	1.6	---	2.1	0.88	---
Total	218.1	106.1	73.0	65.7	48.9	191.2	116.7	92.9	74.6	51.48	44.68	116.6
Mean	7.04	3.54	2.35	2.12	1.75	6.17	3.89	3.00	2.49	1.66	1.44	3.89
Max	33	5.5	3.3	2.5	2.1	12	7.4	6.1	8.5	7.7	5.0	37
Min	2.2	2.4	1.9	1.8	1.6	1.6	2.6	1.3	1.3	0.95	0.86	1.0
Cfsm	2.01	1.01	0.67	0.61	0.50	1.76	1.11	0.86	0.71	0.47	0.41	1.11
In.	2.32	1.13	0.78	0.70	0.52	2.03	1.24	0.99	0.79	0.55	0.47	1.24

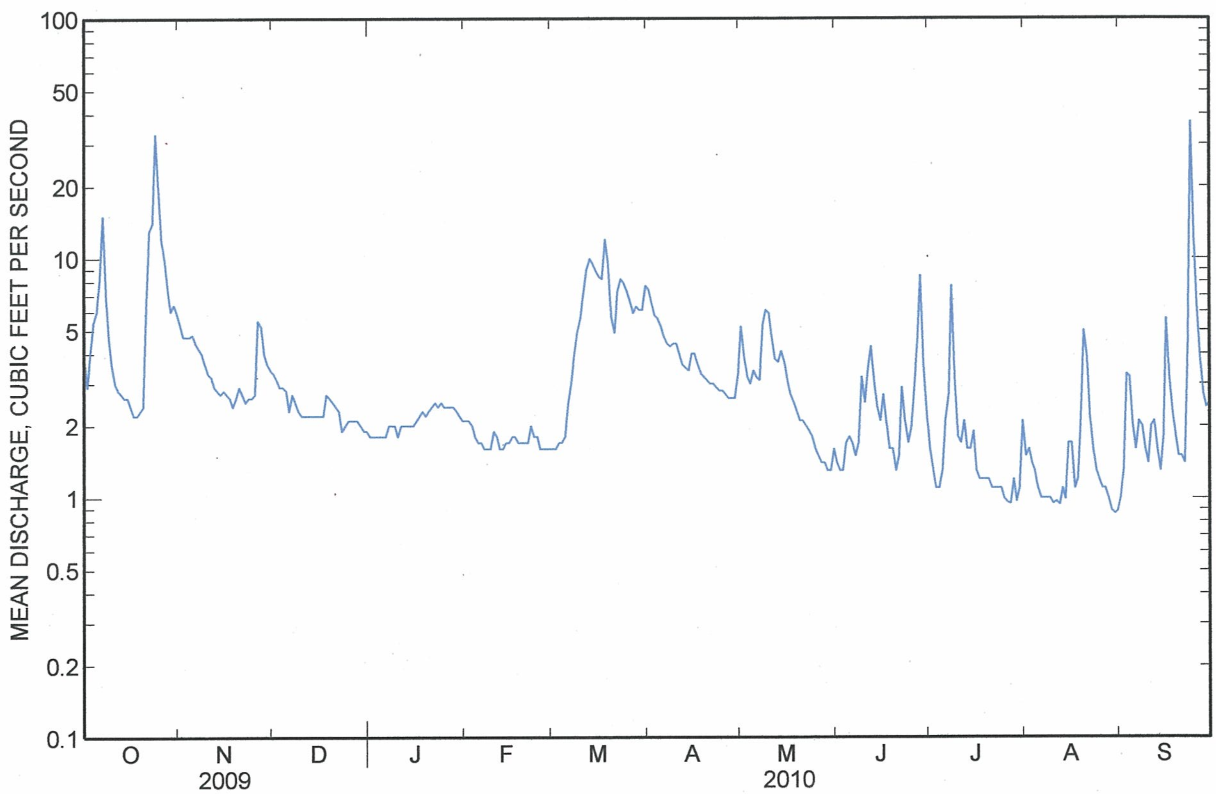
STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 2008 - 2010, BY WATER YEAR (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	5.86	4.07	2.74	2.30	1.91	4.41	11.2	4.80	2.36	2.24	1.97	2.61
Max	7.43	4.88	3.67	3.30	2.16	6.17	18.7	7.02	2.50	2.87	3.04	3.89
(WY)	(2008)	(2008)	(2008)	(2008)	(2008)	(2010)	(2008)	(2008)	(2008)	(2008)	(2009)	(2010)
Min	3.11	3.54	2.20	1.47	1.75	2.17	3.89	3.00	2.10	1.66	1.42	1.52
(WY)	(2009)	(2010)	(2009)	(2009)	(2010)	(2008)	(2010)	(2010)	(2009)	(2010)	(2008)	(2008)

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

SUMMARY STATISTICS

	Calendar Year 2009		Water Year 2010		Water Years 2008 - 2010	
Annual total	1,408.18		1,199.96			
Annual mean	3.86		3.29		3.87	
Highest annual mean					4.80	2008
Lowest annual mean					3.29	2010
Highest daily mean	50	Apr 25	37	Sep 24	50	Apr 22, 2008
Lowest daily mean	0.99	Sep 19	0.86	Aug 30	0.86	Aug 30, 2010
Annual seven-day minimum	1.1	Sep 14	0.98	Aug 26	0.98	Aug 26, 2010
Maximum peak flow			57	Sep 24	69	Apr 25, 2009
Maximum peak stage			3.62	Sep 24	3.77	Apr 25, 2009
Instantaneous low flow					0.60	Jul 28, 2008
Annual runoff (cfsm)	1.10		0.939		1.11	
Annual runoff (inches)	14.97		12.75		15.04	
10 percent exceeds	7.9		6.1		7.4	
50 percent exceeds	2.3		2.3		2.4	
90 percent exceeds	1.2		1.3		1.3	



04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--November 2007 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: November 2007 to current year (not operated during winter months).
WATER TEMPERATURE: November 2007 to current year (not operated during winter months).

INSTRUMENTATION.--Water-quality monitor telemeter, set for one-hour measurement interval.

REMARKS.--Specific conductance records rated excellent except for the following periods: Nov. 26 to Dec. 2, Mar. 15-22, Apr. 8 to May 11, July 2-25, Sept. 18-22, rated good; July 26 to Aug. 10, Sept. 23-27, rated fair; Oct. 1-4, Sept. 28-30, rated poor. Water temperature records rated excellent.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum, 265 microsiemens, July 29, 2008; minimum recorded, 51 microsiemens, Apr. 19, 2008, but may have been lower during period of missing record, Apr. 21-24, 2008.
WATER TEMPERATURE: Maximum, 20.3°C, Aug. 15, 2009; minimum, 0.0°C, on several days during winter periods in water years 2008, 2009.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum, 248 microsiemens, Aug. 13; minimum, 85 microsiemens, Oct. 25.
WATER TEMPERATURE: Maximum, 21.3°C, May. 24 and July 03; minimum, 1.0°C, Nov. 18.

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		October			November			December			January	
1	142	127	135	118	113	115	---	---	---	---	---	---
2	151	142	147	121	118	120	---	---	---	---	---	---
3	151	143	148	123	120	122	---	---	---	---	---	---
4	143	136	140	125	123	124	---	---	---	---	---	---
5	---	---	---	124	120	121	---	---	---	---	---	---
6	---	---	---	124	120	121	---	---	---	---	---	---
7	115	101	104	127	124	125	---	---	---	---	---	---
8	120	105	113	131	126	128	---	---	---	---	---	---
9	131	120	126	133	131	132	---	---	---	---	---	---
10	143	131	137	138	133	135	---	---	---	---	---	---
11	149	143	145	139	137	138	---	---	---	---	---	---
12	155	149	152	144	138	141	---	---	---	---	---	---
13	158	153	155	145	140	144	---	---	---	---	---	---
14	158	155	157	152	140	144	---	---	---	---	---	---
15	161	158	159	152	145	147	---	---	---	---	---	---
16	165	161	162	152	147	149	---	---	---	---	---	---
17	168	165	166	153	151	152	---	---	---	---	---	---
18	169	167	168	157	153	154	---	---	---	---	---	---
19	173	167	170	157	152	155	---	---	---	---	---	---
20	172	170	171	152	148	150	---	---	---	---	---	---
21	172	128	163	150	149	149	---	---	---	---	---	---
22	128	107	113	152	150	151	---	---	---	---	---	---
23	111	100	107	154	151	152	---	---	---	---	---	---
24	100	87	91	155	153	154	---	---	---	---	---	---
25	89	85	87	154	153	154	---	---	---	---	---	---
26	93	89	91	154	126	140	---	---	---	---	---	---
27	98	93	95	128	125	126	---	---	---	---	---	---
28	104	98	101	134	128	131	---	---	---	---	---	---
29	111	104	107	136	134	135	---	---	---	---	---	---
30	112	109	110	138	135	136	---	---	---	---	---	---
31	113	109	111	---	---	---	---	---	---	---	---	---
Month	---	---	---	157	113	138	---	---	---	---	---	---

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	105	96	100	172	158	161
2	---	---	---	---	---	---	110	105	107	171	160	164
3	---	---	---	---	---	---	118	110	113	176	171	173
4	---	---	---	---	---	---	122	118	121	180	175	177
5	---	---	---	---	---	---	126	122	123	180	174	176
6	---	---	---	---	---	---	131	126	128	176	174	175
7	---	---	---	---	---	---	136	131	133	176	175	175
8	---	---	---	---	---	---	136	135	136	175	152	164
9	---	---	---	---	---	---	135	134	134	152	143	146
10	---	---	---	---	---	---	134	132	133	145	138	141
11	---	---	---	---	---	---	140	134	137	156	145	149
12	---	---	---	---	---	---	144	140	141	166	156	161
13	---	---	---	---	---	---	149	144	146	171	166	169
14	---	---	---	---	---	---	151	148	149	170	166	167
15	---	---	---	---	---	---	151	144	149	172	167	168
16	---	---	---	---	---	---	145	142	144	181	172	175
17	---	---	---	---	---	---	151	145	147	188	181	183
18	---	---	---	---	---	---	156	151	153	194	188	190
19	---	---	---	---	---	---	160	155	157	201	194	196
20	---	---	---	---	---	---	163	160	161	205	200	202
21	---	---	---	---	---	---	163	161	162	210	204	207
22	---	---	---	---	---	---	166	163	164	213	207	210
23	---	---	---	---	---	---	168	165	166	217	211	213
24	---	---	---	---	---	---	171	168	169	221	214	217
25	---	---	---	---	---	---	175	170	172	225	217	221
26	---	---	---	---	---	---	176	174	175	225	220	223
27	---	---	---	---	---	---	178	174	176	226	223	225
28	---	---	---	---	---	---	181	177	179	227	223	225
29	---	---	---	---	---	---	183	179	180	229	225	227
30	---	---	---	---	---	---	184	172	181	231	227	229
31	---	---	---	---	---	---	---	---	---	232	222	227
Month	---	---	---	---	---	---	184	96	148	232	138	188

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	232	229	231	178	167	173	223	214	218	244	236	241
2	235	230	232	186	178	183	224	221	222	236	212	233
3	234	230	232	198	186	193	226	224	225	212	193	200
4	235	222	229	203	198	201	228	223	225	193	185	188
5	228	221	223	204	201	203	231	228	229	204	190	197
6	228	225	226	201	193	196	235	231	233	219	204	211
7	228	225	227	198	162	192	238	234	236	217	203	206
8	228	220	226	162	127	134	238	236	237	207	202	204
9	220	204	210	158	134	147	241	237	239	215	207	211
10	214	206	209	177	158	169	243	234	239	228	215	221
11	218	190	208	187	177	182	242	240	241	230	204	217
12	195	188	190	185	179	181	246	241	244	205	203	204
13	204	194	199	191	180	185	248	241	245	217	205	211
14	211	204	207	194	191	193	246	240	243	227	217	222
15	219	211	215	193	187	190	246	206	235	229	200	223
16	217	203	209	202	191	196	235	206	225	200	171	177
17	215	209	212	209	202	206	246	228	235	192	173	183
18	226	215	220	213	209	212	242	231	239	207	192	200
19	229	226	227	217	212	214	231	220	223	220	207	213
20	230	226	228	218	217	217	231	157	200	229	219	223
21	233	219	230	220	217	218	185	169	176	234	229	233
22	219	199	205	222	220	221	202	185	194	241	233	237
23	217	201	211	224	221	222	219	202	210	244	143	231
24	225	217	220	225	223	224	220	218	219	143	87	98
25	227	216	224	225	222	223	223	220	221	104	96	99
26	216	207	210	229	225	226	226	223	224	118	104	111
27	220	147	202	231	226	230	230	226	228	130	118	125
28	147	105	126	229	224	226	232	229	230	141	130	135
29	152	132	143	231	226	229	241	230	235	149	141	145
30	167	152	161	235	219	231	246	239	242	151	149	150
31	---	---	---	220	204	212	245	242	243	---	---	---
Month	235	105	210	235	127	201	248	157	228	244	87	192

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
	October			November			December			January		
1	9.3	6.2	7.6	6.2	4.7	5.5	---	---	---	---	---	---
2	8.3	7.0	7.8	6.4	4.7	5.7	---	---	---	---	---	---
3	9.0	7.9	8.4	4.7	3.4	4.1	---	---	---	---	---	---
4	9.4	8.6	9.0	4.6	3.2	3.8	---	---	---	---	---	---
5	9.8	8.8	9.2	4.7	2.9	4.0	---	---	---	---	---	---
6	8.8	8.2	8.5	5.0	2.5	3.7	---	---	---	---	---	---
7	8.8	7.9	8.3	7.1	5.0	5.8	---	---	---	---	---	---
8	8.7	7.5	8.4	5.6	3.6	4.7	---	---	---	---	---	---
9	8.2	6.1	7.2	6.2	4.2	5.3	---	---	---	---	---	---
10	6.1	4.3	5.3	4.6	2.9	3.6	---	---	---	---	---	---
11	5.3	3.8	4.3	4.9	2.8	3.8	---	---	---	---	---	---
12	4.4	3.2	3.8	5.8	4.3	4.9	---	---	---	---	---	---
13	5.3	3.5	4.1	6.5	5.0	5.7	---	---	---	---	---	---
14	4.7	2.6	3.6	6.9	6.1	6.5	---	---	---	---	---	---
15	5.1	3.6	4.3	6.1	3.3	5.0	---	---	---	---	---	---
16	4.8	2.9	3.8	3.9	2.2	2.9	---	---	---	---	---	---
17	5.2	3.4	4.3	3.0	1.3	2.0	---	---	---	---	---	---
18	6.4	3.4	4.7	2.9	1.0	1.9	---	---	---	---	---	---
19	8.3	5.7	6.8	4.3	2.1	3.3	---	---	---	---	---	---
20	7.3	6.5	6.8	5.9	3.8	4.8	---	---	---	---	---	---
21	6.5	5.5	6.2	4.0	2.3	3.2	---	---	---	---	---	---
22	5.5	4.6	5.2	5.9	3.3	4.6	---	---	---	---	---	---
23	4.8	4.4	4.6	6.9	5.7	6.2	---	---	---	---	---	---
24	4.6	3.5	3.9	6.0	5.6	5.8	---	---	---	---	---	---
25	4.3	3.4	3.9	6.1	5.5	5.7	---	---	---	---	---	---
26	5.6	4.3	5.0	5.6	3.0	4.4	---	---	---	---	---	---
27	6.2	5.0	5.5	3.0	2.3	2.6	---	---	---	---	---	---
28	5.8	4.0	4.9	2.9	1.8	2.3	---	---	---	---	---	---
29	7.3	5.3	6.4	2.9	2.3	2.6	---	---	---	---	---	---
30	10.0	7.3	8.5	2.8	2.2	2.4	---	---	---	---	---	---
31	8.3	5.7	6.6	---	---	---	---	---	---	---	---	---
Month	10.0	2.6	6.0	7.1	1.0	4.2	---	---	---	---	---	---

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	9.9	5.5	7.5	15.5	10.0	12.0
2	---	---	---	---	---	---	12.6	6.8	9.7	15.1	9.7	11.9
3	---	---	---	---	---	---	11.0	6.9	9.7	11.1	8.5	9.8
4	---	---	---	---	---	---	8.8	5.7	6.9	14.0	7.8	10.3
5	---	---	---	---	---	---	10.4	5.0	7.4	11.4	8.5	9.8
6	---	---	---	---	---	---	8.8	6.0	7.4	12.1	6.9	8.9
7	---	---	---	---	---	---	8.8	4.6	6.1	7.6	3.9	5.9
8	---	---	---	---	---	---	4.7	2.6	3.5	7.6	3.0	4.8
9	---	---	---	---	---	---	7.5	1.6	3.9	9.0	3.4	5.8
10	---	---	---	---	---	---	9.5	3.5	5.9	11.2	4.2	7.3
11	---	---	---	---	---	---	10.0	3.6	6.3	9.4	7.0	7.9
12	---	---	---	---	---	---	9.7	5.1	7.0	13.3	6.6	9.2
13	---	---	---	---	---	---	8.3	4.6	6.5	8.9	8.1	8.4
14	---	---	---	---	---	---	13.0	6.3	9.2	8.5	7.2	8.2
15	---	---	---	---	---	---	13.4	10.0	11.2	14.0	5.7	9.3
16	---	---	---	---	---	---	10.4	6.0	8.1	16.0	8.0	11.5
17	---	---	---	---	---	---	9.2	4.3	6.2	16.5	8.9	12.2
18	---	---	---	---	---	---	10.7	3.8	6.6	16.5	8.3	12.0
19	---	---	---	---	---	---	10.4	3.7	6.7	17.4	9.4	12.9
20	---	---	---	---	---	---	12.5	4.8	7.9	16.9	9.8	12.8
21	---	---	---	---	---	---	6.8	3.2	5.1	15.0	9.5	12.2
22	---	---	---	---	---	---	9.8	1.5	5.0	14.1	11.0	12.4
23	---	---	---	---	---	---	12.4	3.6	7.5	18.6	12.2	15.1
24	---	---	---	---	---	---	10.6	6.6	8.5	21.3	14.7	17.6
25	---	---	---	---	---	---	12.6	5.6	8.5	21.2	16.3	18.4
26	---	---	---	---	---	---	11.6	4.4	7.4	18.2	14.3	16.4
27	---	---	---	---	---	---	11.1	3.5	6.7	17.4	11.4	14.1
28	---	---	---	---	---	---	11.8	2.9	6.9	16.9	10.6	13.5
29	---	---	---	---	---	---	10.2	5.8	8.0	17.9	10.8	13.9
30	---	---	---	---	---	---	14.4	7.9	10.6	19.3	13.1	15.7
31	---	---	---	---	---	---	---	---	---	17.7	13.1	15.1
Month	---	---	---	---	---	---	14.4	1.5	7.3	21.3	3.0	11.5

04043140 GOMANCHE CREEK AT INDIAN ROAD NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	17.9	12.0	14.6	14.1	10.2	12.1	18.6	14.2	16.1	18.3	14.4	16.9
2	15.8	12.2	13.8	19.3	12.9	15.5	17.1	15.6	16.3	15.5	13.0	14.1
3	15.9	9.7	12.5	21.3	15.1	17.7	20.2	15.5	17.3	14.8	11.4	13.2
4	12.8	11.3	12.0	20.5	17.3	18.6	19.2	15.5	17.1	11.7	10.7	11.2
5	12.6	11.0	11.7	18.3	15.9	17.0	17.6	14.7	16.1	13.0	9.5	10.9
6	14.6	10.3	11.9	19.3	15.4	16.9	16.6	12.8	14.4	13.7	10.0	11.6
7	14.5	7.9	10.9	20.1	15.6	17.3	16.3	12.2	14.1	12.8	11.2	12.3
8	12.5	9.8	11.0	19.8	16.8	18.2	17.6	14.1	15.5	11.7	10.2	11.0
9	13.5	10.8	12.0	19.6	15.9	17.4	18.9	14.4	16.2	11.9	9.4	10.5
10	14.3	10.7	12.1	19.8	14.4	16.8	19.1	15.0	16.8	12.7	8.0	10.3
11	12.3	11.4	11.8	18.0	16.1	16.9	17.9	16.0	16.8	12.4	11.1	11.8
12	12.3	11.2	11.8	18.5	14.4	16.0	20.2	16.1	17.7	13.2	10.8	11.8
13	13.7	11.7	12.5	17.8	12.7	15.1	19.9	16.8	17.9	12.8	10.1	11.3
14	16.1	11.9	13.5	16.5	14.6	15.7	20.2	16.0	17.8	11.9	9.1	10.1
15	13.9	12.4	13.0	19.6	15.9	17.2	17.9	15.8	16.5	9.9	7.3	8.9
16	13.7	11.8	12.6	20.1	15.5	17.4	16.8	14.1	15.1	11.2	9.8	10.3
17	17.1	11.3	14.0	19.5	15.2	17.0	15.8	12.5	13.9	11.0	9.5	10.3
18	19.4	14.8	16.6	17.5	14.8	15.9	14.7	13.1	13.8	11.2	8.5	10.1
19	16.6	14.4	15.2	18.5	14.2	16.0	16.1	12.9	14.1	10.7	7.4	8.7
20	17.7	12.6	14.8	16.2	14.4	15.3	16.3	13.5	14.7	10.5	6.2	8.3
21	17.5	12.3	14.7	18.4	13.7	15.6	16.6	14.8	15.8	14.0	10.5	12.4
22	17.7	13.5	15.2	16.0	13.7	14.7	17.5	13.7	15.2	11.7	8.7	10.2
23	16.1	14.9	15.5	17.8	14.1	15.6	18.7	14.2	16.0	11.9	10.2	10.8
24	17.8	14.1	15.4	15.7	13.9	14.7	16.8	14.8	16.2	13.1	11.4	12.5
25	14.6	13.6	14.2	17.9	12.8	14.9	14.9	12.6	13.8	11.4	9.4	10.6
26	17.9	13.8	15.3	18.9	13.3	15.7	15.1	10.8	12.7	10.2	7.7	9.0
27	17.1	14.4	15.4	18.8	15.4	17.0	17.4	11.8	14.2	10.9	8.2	9.6
28	17.0	14.0	15.7	18.8	15.4	16.9	18.9	14.8	16.4	10.4	9.8	10.2
29	15.2	11.9	13.3	17.8	13.7	15.5	19.3	15.2	16.9	11.8	9.3	10.4
30	15.6	10.2	12.5	18.1	14.0	15.8	21.1	16.7	18.5	11.6	9.3	10.4
31	---	---	---	16.9	14.5	15.4	19.6	17.9	18.7	---	---	---
Month	19.4	7.9	13.5	21.3	10.2	16.2	21.1	10.8	15.9	18.3	6.2	11.0

science for a changing world

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI

Southcentral Lake Superior Basin
Dead-Kelsey Subbasin

LOCATION.--Lat 46°43'16", long 88°19'48" referenced to North American Datum of 1927, in NW ¼ NE ¼ sec.20, T.50 N., R.32 W., Baraga County, MI, Hydrologic Unit 04020105, upstream from East Branch Silver River, at two track road, 6.0 mi southeast of L'Anse.

DRAINAGE AREA.--16.8 mi^2.

SURFACE-WATER RECORDS

PERIOD OF RECORD.--May 2005 to September 2008 (miscellaneous discharge measurements only), October 2008 to current year.

GAGE.--Water-stage recorder and crest-stage gage. Elevation of gage is 1,295 ft above sea level, from topograghic map.

REMARKS.--Records good except for estimated daily discharges, which are fair. Gage-height telemeter at station.

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010
DAILY MEAN VALUES
[e, estimated]

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	50	48	21	e14	e14	e15	81	18	5.7	15	8.5	13
2	34	43	20	e13	e14	e15	82	16	5.4	11	9.4	12
3	39	39	e19	e13	e14	e16	74	14	5.2	8.8	9.1	40
4	43	36	e19	e13	e14	e16	58	13	6.3	7.6	7.9	61
5	51	36	e18	e13	e14	e16	45	14	7.2	7.9	7.0	42
6	67	34	e17	e13	e14	e17	37	14	6.4	16	6.4	25
7	132	35	e17	e13	e14	e18	32	14	5.7	69	5.8	25
8	86	31	e16	e13	e14	e21	29	18	6.2	346	5.6	27
9	52	30	e17	e13	e14	e22	28	24	17	122	5.5	21
10	39	28	e17	e12	e14	e34	30	26	12	55	5.2	16
11	31	25	e17	e12	e14	e58	27	22	15	36	5.0	17
12	27	24	e17	e12	e14	e83	24	19	22	30	4.9	22
13	25	22	e17	e12	e14	97	21	17	19	23	4.8	17
14	24	22	e17	e12	e14	102	20	19	16	19	4.8	12
15	22	20	e17	e11	e14	107	21	18	12	23	6.3	11
16	20	19	e16	e11	e14	110	21	16	14	19	6.0	41
17	19	e18	e16	e11	e15	112	19	14	12	15	5.1	35
18	18	17	e16	e11	e15	132	17	12	9.5	13	5.1	25
19	18	18	e16	e11	e15	130	15	11	8.1	12	8.5	19
20	17	19	e15	e11	e15	e83	14	9.8	7.6	11	15	15
21	31	19	e15	e12	e15	e62	14	9.0	7.5	10	18	12
22	69	18	e15	e13	e15	50	13	8.5	21	9.1	14	10
23	82	17	e14	e13	e15	46	12	8.2	16	8.6	11	28
24	121	17	e15	e14	e15	45	12	7.6	13	8.3	8.9	295
25	97	17	e15	e14	e15	43	11	6.9	13	7.6	7.5	199
26	99	32	e16	e14	e15	e38	10	6.5	19	7.2	6.7	96
27	105	29	e16	e14	e15	32	9.9	6.1	33	6.8	6.1	56
28	83	26	e15	e14	e15	33	9.6	5.9	38	8.0	5.6	38
29	63	24	e15	e14	---	30	9.0	5.5	27	6.9	4.9	32
30	62	22	e14	e14	---	32	11	5.3	18	6.9	4.7	31
31	56	---	e14	e14	---	56	---	6.9	---	12	4.5	---
Total	1,682	785	509	394	404	1,671	806.5	405.2	417.8	950.7	227.8	1,293
Mean	54.3	26.2	16.4	12.7	14.4	53.9	26.9	13.1	13.9	30.7	7.35	43.1
Max	132	48	21	14	15	132	82	26	38	346	18	295
Min	17	17	14	11	14	15	9.0	5.3	5.2	6.8	4.5	10
Cfsm	3.23	1.56	0.98	0.76	0.86	3.21	1.60	0.78	0.83	1.83	0.44	2.57
In.	3.72	1.74	1.13	0.87	0.89	3.70	1.79	0.90	0.93	2.11	0.50	2.86

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 2009 - 2010, BY WATER YEAR (WY)

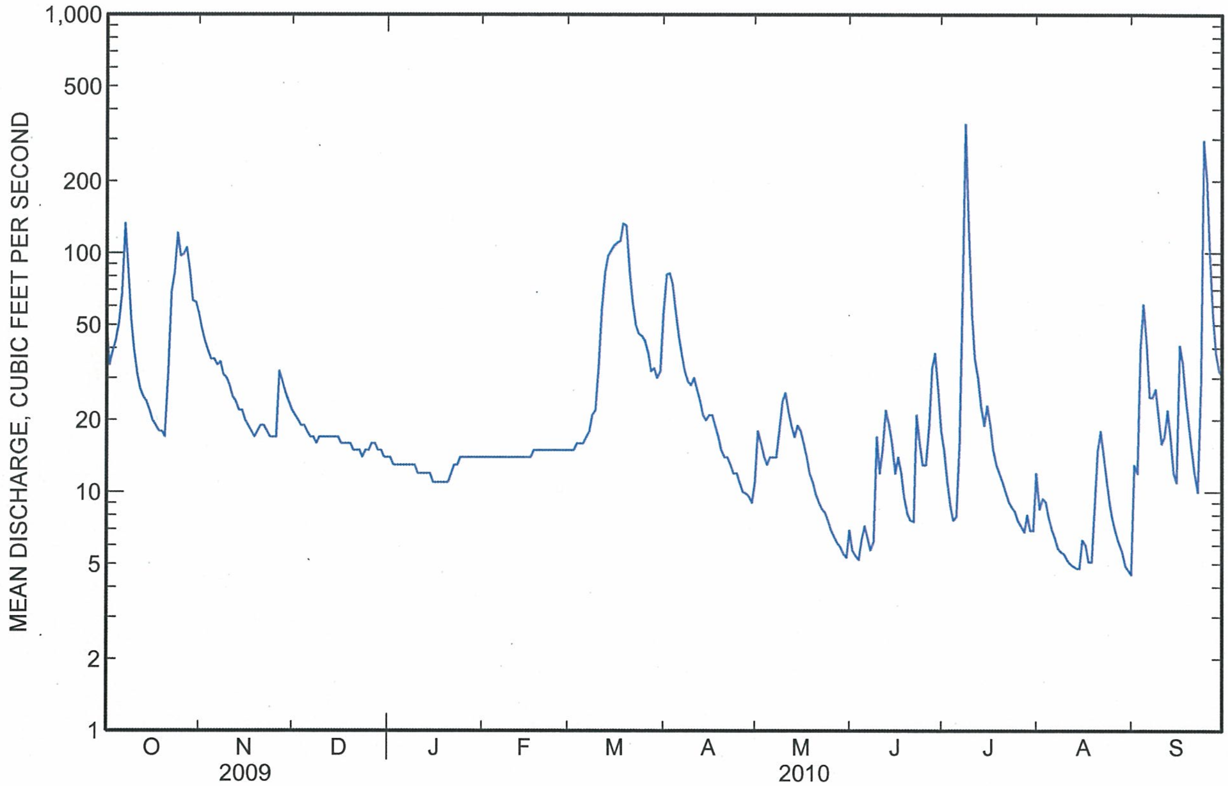
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	32.7	22.3	12.7	9.18	10.6	34.5	60.2	26.4	12.9	23.9	14.7	30.9
Max	54.3	26.2	16.4	12.7	14.4	53.9	93.5	39.7	13.9	30.7	22.0	43.1
(WY)	(2010)	(2010)	(2010)	(2010)	(2010)	(2010)	(2009)	(2009)	(2010)	(2010)	(2009)	(2010)
Min	11.1	18.4	8.89	5.64	6.69	15.1	26.9	13.1	11.8	17.2	7.35	18.8
(WY)	(2009)	(2009)	(2009)	(2009)	(2009)	(2009)	(2010)	(2010)	(2009)	(2009)	(2010)	(2009)

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

SUMMARY STATISTICS

	Calendar Year 2009		Water Year 2010		Water Years 2009 - 2010	
Annual total	9,973.6		9,546.0			
Annual mean	27.3		26.2		24.3	
Highest annual mean					26.2	2010
Lowest annual mean					22.4	2009
Highest daily mean	313	Apr 25	346	Jul 8	346	Jul 8, 2010
Lowest daily mean	4.2	Sep 19	4.5	Aug 31	4.2	Sep 19, 2009
Annual seven-day minimum	4.3	Sep 19	5.1	Aug 8	4.3	Sep 19, 2009
Maximum peak flow			423	Jul 8	423	Jul 8, 2010
Maximum peak stage			8.17	Jul 8	8.17	Jul 8, 2010
Instantaneous low flow			4.2	Aug 30[a]	3.7	Sep 24, 2009
Annual runoff (cfsm)	1.63		1.56		1.44	
Annual runoff (inches)	22.08		21.14		19.63	
10 percent exceeds	65		56		51	
50 percent exceeds	13		16		14	
90 percent exceeds	5.0		7.0		5.6	

[a] Also occurred Aug. 31.



04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

WATER-QUALITY RECORDS

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 2008 to current year (not operated during winter months).
WATER TEMPERATURE: October 2008 to current year (not operated during winter months).

INSTRUMENTATION.--Water-quality monitor telemeter, set for one-hour measurement interval.

REMARKS.--Specific conductance records rated excellent except for the following periods: Oct. 28 to Dec. 2, Mar. 8, 9, Mar. 18 to Apr. 8, Aug. 24 to Sept. 15, rated good; Apr. 9-23, rated fair; Oct. 1-6, Apr. 24 to May 11, rated poor.

EXTREMES OUTSIDE PERIOD OF RECORD.--A specific conductance of 144 microsiemens was measured Sept. 12, 2006, July 25, 2007.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum, 135 microsiemens, Aug. 13; minimum recorded, 32 microsiemens, Oct. 7, 8.
WATER TEMPERATURE: Maximum, 24.5°C, May 25; minimum, 0.2°C, on Nov. 18.

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		October			November			December			January	
1	43	39	41	42	40	41	---	---	---	---	---	---
2	48	43	45	44	42	43	---	---	---	---	---	---
3	48	47	48	44	43	43	---	---	---	---	---	---
4	47	45	47	45	44	44	---	---	---	---	---	---
5	45	43	44	46	45	46	---	---	---	---	---	---
6	43	40	42	47	46	46	---	---	---	---	---	---
7	40	32	35	47	46	46	---	---	---	---	---	---
8	36	32	33	48	46	47	---	---	---	---	---	---
9	40	36	38	49	48	48	---	---	---	---	---	---
10	45	40	43	50	48	50	---	---	---	---	---	---
11	50	45	47	52	50	51	---	---	---	---	---	---
12	54	50	51	54	52	53	---	---	---	---	---	---
13	54	52	53	55	54	55	---	---	---	---	---	---
14	56	52	54	56	55	56	---	---	---	---	---	---
15	57	55	56	57	56	57	---	---	---	---	---	---
16	59	57	58	59	57	58	---	---	---	---	---	---
17	60	59	59	61	59	60	---	---	---	---	---	---
18	63	60	62	63	61	62	---	---	---	---	---	---
19	65	63	64	64	63	64	---	---	---	---	---	---
20	67	65	66	63	61	62	---	---	---	---	---	---
21	69	61	67	61	61	61	---	---	---	---	---	---
22	61	45	52	62	61	61	---	---	---	---	---	---
23	45	42	43	63	62	62	---	---	---	---	---	---
24	42	37	39	63	62	62	---	---	---	---	---	---
25	38	36	37	64	63	64	---	---	---	---	---	---
26	38	36	37	65	54	59	---	---	---	---	---	---
27	36	35	35	54	53	53	---	---	---	---	---	---
28	37	35	35	54	53	53	---	---	---	---	---	---
29	39	36	38	54	53	53	---	---	---	---	---	---
30	41	39	40	56	54	55	---	---	---	---	---	---
31	41	40	40	---	---	---	---	---	---	---	---	---
Month	69	32	47	65	40	54	---	---	---	---	---	---

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	43	38	41	78	69	71
2	---	---	---	---	---	---	39	35	38	70	68	69
3	---	---	---	---	---	---	36	34	35	70	68	69
4	---	---	---	---	---	---	37	34	35	73	69	72
5	---	---	---	---	---	---	39	37	38	73	71	72
6	---	---	---	---	---	---	42	39	41	71	68	69
7	---	---	---	---	---	---	45	42	44	68	67	67
8	---	---	---	---	---	---	46	44	45	67	64	66
9	---	---	---	---	---	---	48	46	47	65	59	64
10	---	---	---	---	---	---	48	47	47	59	55	56
11	---	---	---	---	---	---	48	46	47	58	55	56
12	---	---	---	---	---	---	51	48	49	63	58	60
13	---	---	---	---	---	---	54	51	53	66	63	65
14	---	---	---	---	---	---	57	54	56	67	64	65
15	---	---	---	---	---	---	58	57	57	66	64	65
16	---	---	---	---	---	---	59	57	58	68	64	66
17	---	---	---	---	---	---	59	57	58	73	67	70
18	---	---	---	---	---	---	61	59	60	85	72	79
19	---	---	---	---	---	---	63	61	62	90	82	85
20	---	---	---	---	---	---	67	63	65	91	85	88
21	---	---	---	---	---	---	67	66	66	90	87	88
22	---	---	---	---	---	---	69	66	67	93	90	92
23	---	---	---	---	---	---	69	68	69	96	93	94
24	---	---	---	---	---	---	71	68	70	101	96	98
25	---	---	---	---	---	---	73	71	71	106	101	103
26	---	---	---	---	---	---	76	73	74	109	106	108
27	---	---	---	---	---	---	77	75	76	113	109	111
28	---	---	---	---	---	---	80	75	77	116	113	115
29	---	---	---	---	---	---	81	79	80	119	116	117
30	---	---	---	---	---	---	83	78	81	122	119	120
31	---	---	---	---	---	---	---	---	---	122	120	121
Month	---	---	---	---	---	---	83	34	57	122	55	82

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	123	120	121	78	75	76	109	106	106	126	79	97
2	123	121	122	87	78	83	109	105	107	89	84	87
3	126	123	124	99	87	91	107	104	105	86	61	72
4	126	121	125	103	98	100	112	107	108	61	50	54
5	121	116	118	107	102	104	113	108	110	52	49	51
6	120	117	118	107	90	98	114	110	112	59	52	55
7	123	119	120	90	44	81	119	113	115	64	59	62
8	123	118	121	44	33	36	122	117	119	61	56	57
9	118	91	98	41	33	37	124	120	122	59	55	57
10	93	92	92	49	41	45	124	118	123	64	59	62
11	96	81	92	60	49	54	127	124	125	68	64	66
12	81	73	76	65	59	62	128	126	127	65	59	62
13	73	72	73	78	65	71	135	128	131	63	59	61
14	79	73	75	81	76	78	131	128	129	69	63	66
15	82	75	78	82	71	78	131	122	126	78	69	71
16	85	81	84	77	70	73	128	121	123	77	50	59
17	87	84	85	85	77	80	126	122	123	50	48	49
18	93	87	90	89	85	87	133	126	129	54	50	52
19	99	93	96	94	87	90	126	114	120	60	54	57
20	102	99	100	94	90	92	115	93	109	66	59	62
21	108	102	104	101	93	97	93	86	89	72	66	69
22	108	76	85	101	97	99	88	86	87	76	72	74
23	79	77	78	104	101	102	94	88	91	79	50	76
24	82	79	80	105	102	103	100	94	97	50	36	40
25	87	82	84	108	105	107	104	100	102	36	35	35
26	86	77	81	110	107	108	109	104	107	40	36	37
27	77	68	72	113	110	111	114	109	112	45	40	42
28	68	63	65	113	111	112	119	114	115	49	45	47
29	68	63	65	114	111	112	122	117	119	54	49	52
30	75	68	71	118	110	115	125	122	124	55	54	54
31	---	---	---	113	103	106	126	124	125	---	---	---
Month	126	63	93	118	33	87	135	86	114	126	35	60

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		October			November			December			January	
1	8.0	5.6	6.8	5.2	4.1	4.7	---	---	---	---	---	---
2	7.5	6.8	7.2	5.6	4.2	5.0	---	---	---	---	---	---
3	8.3	7.2	7.7	4.2	2.5	3.1	---	---	---	---	---	---
4	8.9	8.0	8.4	3.3	1.9	2.6	---	---	---	---	---	---
5	9.4	8.2	8.7	3.3	2.3	2.9	---	---	---	---	---	---
6	8.6	7.7	8.0	3.7	1.5	2.5	---	---	---	---	---	---
7	8.0	7.2	7.6	5.2	3.7	4.4	---	---	---	---	---	---
8	7.8	7.1	7.5	4.5	2.8	3.6	---	---	---	---	---	---
9	7.4	6.1	6.8	4.8	4.0	4.5	---	---	---	---	---	---
10	6.1	4.0	5.1	4.0	2.4	3.0	---	---	---	---	---	---
11	4.2	3.3	3.7	3.4	1.8	2.6	---	---	---	---	---	---
12	3.4	2.6	3.0	4.1	2.9	3.5	---	---	---	---	---	---
13	3.8	2.6	3.2	5.2	3.7	4.3	---	---	---	---	---	---
14	3.7	1.8	2.8	5.7	5.0	5.3	---	---	---	---	---	---
15	4.0	3.1	3.6	5.4	3.0	4.3	---	---	---	---	---	---
16	3.5	2.1	2.9	3.0	1.4	2.1	---	---	---	---	---	---
17	4.0	2.8	3.5	1.9	0.6	1.2	---	---	---	---	---	---
18	4.9	2.6	3.7	1.6	0.2	0.9	---	---	---	---	---	---
19	6.8	4.5	5.6	3.5	1.6	2.5	---	---	---	---	---	---
20	6.8	6.1	6.3	4.6	3.5	3.9	---	---	---	---	---	---
21	6.1	4.5	5.7	3.7	1.7	2.4	---	---	---	---	---	---
22	4.8	4.0	4.4	4.7	2.4	3.3	---	---	---	---	---	---
23	4.0	2.8	3.8	5.5	4.6	5.0	---	---	---	---	---	---
24	2.8	1.7	2.0	5.2	4.7	4.9	---	---	---	---	---	---
25	2.9	1.7	2.3	5.1	4.7	4.9	---	---	---	---	---	---
26	4.3	2.9	3.5	5.0	2.0	3.4	---	---	---	---	---	---
27	4.9	3.9	4.3	2.0	1.3	1.6	---	---	---	---	---	---
28	5.2	3.3	4.2	1.5	0.6	1.1	---	---	---	---	---	---
29	6.8	4.8	5.7	1.6	1.3	1.4	---	---	---	---	---	---
30	9.0	6.8	7.9	1.4	1.0	1.2	---	---	---	---	---	---
31	8.0	5.0	6.0	---	---	---	---	---	---	---	---	---
Month	9.4	1.7	5.2	5.7	0.2	3.2	---	---	---	---	---	---

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	8.8	4.8	6.8	15.6	11.7	13.7
2	---	---	---	---	---	---	11.5	7.8	9.4	14.4	10.9	13.0
3	---	---	---	---	---	---	11.0	8.1	10	13.6	10.5	11.2
4	---	---	---	---	---	---	8.6	6.5	7.4	13.0	9.2	11.1
5	---	---	---	---	---	---	10.1	5.8	7.8	11.8	9.9	11.1
6	---	---	---	---	---	---	8.9	6.6	7.8	11.8	8.3	10.2
7	---	---	---	---	---	---	8.6	5.5	7.0	10.7	5.2	7.6
8	---	---	---	---	---	---	6.2	3.0	4.1	6.5	2.8	4.7
9	---	---	---	---	---	---	6.9	1.8	4.1	8.8	3.4	6.1
10	---	---	---	---	---	---	8.5	3.7	5.9	11.1	4.2	7.6
11	---	---	---	---	---	---	9.3	3.9	6.6	9.6	7.2	8.2
12	---	---	---	---	---	---	9.0	5.3	7.3	12.4	7.0	9.7
13	---	---	---	---	---	---	8.1	5.6	7.1	11.8	8.8	9.5
14	---	---	---	---	---	---	12.1	6.5	9.2	9.2	8.4	8.8
15	---	---	---	---	---	---	13.3	10.3	11.7	13.4	6.7	10.1
16	---	---	---	---	---	---	12.2	6.9	9.0	14.8	9.7	12.6
17	---	---	---	---	---	---	8.0	4.7	6.5	15.7	10.9	13.6
18	---	---	---	---	---	---	9.6	4.8	7.4	16.3	11.2	14.1
19	---	---	---	---	---	---	9.7	5.2	7.8	17.6	12.6	15.2
20	---	---	---	---	---	---	11.4	6.6	9.2	18.0	13.3	15.7
21	---	---	---	---	---	---	10.0	4.7	6.5	17.2	14.2	15.7
22	---	---	---	---	---	---	8.3	2.7	5.7	15.8	14.5	15.0
23	---	---	---	---	---	---	10.7	5.5	8.4	19.4	14.4	16.8
24	---	---	---	---	---	---	10.4	8.2	9.4	23.0	18.3	20.4
25	---	---	---	---	---	---	12.2	7.8	9.9	24.5	19.9	21.8
26	---	---	---	---	---	---	11.3	7.0	9.2	22.1	18.2	20.5
27	---	---	---	---	---	---	10.9	6.3	8.6	21.1	15.6	18.0
28	---	---	---	---	---	---	11.2	5.8	8.5	20.5	14.6	17.2
29	---	---	---	---	---	---	9.8	7.9	9.0	21.4	14.9	17.8
30	---	---	---	---	---	---	13.5	9.0	11.1	22.9	17.2	19.6
31	---	---	---	---	---	---	---	---	---	21.6	17.5	19.1
Month	---	---	---	---	---	---	13.5	1.8	7.9	24.5	2.8	13.4

04043126 SILVER RIVER UPSTREAM OF EAST BRANCH NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	20.6	16.2	18.1	16.0	12.8	14.2	20.6	16.8	18.7	20.5	18.0	19.4
2	19.3	15.6	17.2	20.2	14.8	17.5	19.8	18.6	19.3	18.0	15.3	16.4
3	19.6	13.2	16.1	22.7	18.1	20.3	22.8	18.8	20.6	16.7	12.7	14.8
4	15.8	13.6	14.7	22.9	20.6	21.5	21.8	19.0	20.5	12.7	11.8	12.3
5	14.6	13.1	13.9	21.3	19.6	20.3	20.4	18.0	19.2	13.5	10.7	12.0
6	17.4	12.9	14.5	21.9	18.6	20.2	19.4	15.6	17.4	15.0	11.4	13.0
7	17.7	11.7	14.4	22.5	18.4	20.3	18.6	15.0	16.9	14.2	12.4	13.7
8	15.2	12.3	13.5	20.2	18.2	19.2	20.8	17.0	18.7	12.4	11.4	11.9
9	14.3	11.6	13.0	21.0	18.2	19.4	22.1	18.2	19.9	12.7	10.4	11.5
10	14.9	12.5	13.7	21.5	17.2	19.2	22.7	18.4	20.5	13.3	9.4	11.5
11	14.6	12.7	13.6	20.2	18.8	19.4	21.4	19.9	20.5	12.8	11.9	12.4
12	13.4	12.1	12.8	20.9	16.9	18.8	23.5	19.4	21.1	14.1	11.3	12.6
13	14.8	12.9	13.8	20.2	15.4	17.9	23.7	20.7	21.9	13.3	11.6	12.5
14	17.3	13.6	15.4	18.7	16.7	17.7	23.7	19.4	21.4	12.8	10.5	11.6
15	16.7	14.6	15.3	21.5	17.4	19.2	21.5	17.6	19.5	11.5	8.7	10.0
16	15.1	13.8	14.5	21.8	17.5	19.7	17.9	15.9	16.8	11.6	10.1	10.6
17	18.2	13.4	15.8	21.6	17.7	19.8	18.3	14.2	15.9	11.1	9.7	10.4
18	20.9	17.3	19.0	20.2	17.5	18.6	16.5	14.9	15.7	11.6	9.5	10.8
19	19.7	16.9	18.2	20.2	16.6	18.5	18.3	14.7	16.3	10.7	8.0	9.4
20	19.6	15.6	17.4	19.2	17.2	18.1	16.6	15.6	16.1	10.8	7.2	9.0
21	20.9	16.4	18.2	20.3	16.2	18.2	17.5	16.0	16.7	14.1	10.8	12.7
22	19.5	15.9	17.7	19.1	16.7	17.5	18.7	14.9	16.9	12.9	9.8	11.4
23	19.3	17.5	18.2	20.0	16.8	18.2	19.9	15.9	18.1	12.9	11.2	11.8
24	19.8	16.5	18.1	18.7	16.9	17.5	19.3	17.1	18.2	13.5	11.8	13.0
25	18.5	16.4	16.9	20.2	15.2	17.6	17.1	14.9	16.0	11.8	9.8	10.8
26	19.1	15.7	17.3	21.0	16.4	18.7	16.8	12.8	14.7	10.1	8.1	9.2
27	18.6	16.6	17.5	21.2	18.5	19.9	18.9	13.9	16.2	10.6	8.2	9.5
28	17.6	15.7	16.7	21.6	19.0	20.0	20.9	16.6	18.4	10.4	9.9	10.2
29	17.2	13.5	15.4	20.6	16.9	18.7	21.4	17.1	19.0	11.7	9.4	10.4
30	17.0	12.2	14.8	20.9	17.2	19.0	23.2	18.7	20.6	12.0	10.1	10.9
31	---	---	---	19.3	17.6	18.5	21.5	19.8	20.7	---	---	---
Month	20.9	11.6	15.9	22.9	12.8	18.8	23.7	12.8	18.5	20.5	7.2	11.9

USGS
science for a changing world

Water-Data Report 2010

04043150 SILVER RIVER NEAR L'ANSE, MI

Southcentral Lake Superior Basin
Dead-Kelsey Subbasin

LOCATION.--Lat 46°48'15", long 88°19'01" referenced to North American Datum of 1927, in SW ¼ NW ¼ sec.24, T.51 N., R.32 W., Baraga County, MI, Hydrologic Unit 04020105, on left bank, 30 ft upstream from bridge on Skanee Road, 2.0 mi upstream from mouth, and 7.5 mi northeast of L'Anse.

DRAINAGE AREA.--64.7 mi^2, revised.

SURFACE-WATER RECORDS

PERIOD OF RECORD.--October 2001 to current year.

REVISED RECORDS.--WDR MI-03-1: 2002(M).

GAGE.--Water-stage recorder and crest-stage gage. Elevation of gage is 630 ft above sea level, from topographic map.

REMARKS.--Records good except for estimated daily discharges, which are fair. Gage-height telemeter at station.

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010
DAILY MEAN VALUES
[e, estimated]

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	122	133	60	e44	e44	e46	224	58	14	29	22	16
2	78	120	57	e42	e42	e46	204	45	12	24	21	21
3	95	109	53	e40	e41	e46	176	38	11	19	22	58
4	112	100	e53	e40	e40	e46	142	35	12	17	20	103
5	124	96	e53	e38	e39	e47	116	37	17	19	17	83
6	153	89	e53	e37	e39	e48	97	37	16	28	15	52
7	365	87	e53	e37	e39	e48	84	35	14	30	14	48
8	237	80	e52	e37	e39	e52	76	57	13	405	13	52
9	141	75	e52	e37	e39	e72	75	76	28	206	13	41
10	102	69	e52	e37	e39	e97	78	83	27	103	12	34
11	81	64	e51	e37	e39	e129	71	73	28	66	11	34
12	70	60	e51	e37	e39	e173	63	58	53	64	11	45
13	63	54	e51	e37	e39	e239	56	50	42	44	11	35
14	60	53	e50	e37	e39	e300	51	55	35	35	11	28
15	54	50	e49	e36	e40	e374	54	50	28	44	14	25
16	50	47	e48	e36	e44	410	56	43	32	36	16	84
17	46	45	e46	e37	e46	401	49	37	28	28	13	78
18	44	41	e46	e37	e47	459	44	32	23	25	12	58
19	41	42	e45	e38	e47	474	41	29	19	23	21	41
20	39	49	e46	e38	e46	294	38	26	19	22	45	34
21	66	47	e45	e42	e46	217	36	23	17	22	52	29
22	230	45	e45	e47	e46	184	35	22	34	20	32	27
23	244	44	e46	e49	e46	170	34	21	32	18	25	31
24	547	42	e46	e51	e46	163	32	20	27	18	21	559
25	374	42	e46	e51	e46	155	30	18	25	17	18	407
26	293	80	e48	e51	e46	125	29	17	35	15	16	218
27	272	90	e50	e51	e46	116	28	15	47	14	14	137
28	220	75	e49	e51	e46	119	26	14	88	17	13	96
29	171	68	e48	e51	---	110	26	13	58	15	11	77
30	167	63	e47	e49	---	109	28	13	37	14	10	74
31	151	---	e45	e47	---	160	---	15	---	26	9.6	---
Total	4,812	2,059	1,536	1,299	1,195	5,429	2,099	1,145	871	1,463	555.6	2,625
Mean	155	68.6	49.5	41.9	42.7	175	70.0	36.9	29.0	47.2	17.9	87.5
Max	547	133	60	51	47	474	224	83	88	405	52	559
Min	39	41	45	36	39	46	26	13	11	14	9.6	16
Cfsm	2.40	1.06	0.77	0.65	0.66	2.71	1.08	0.57	0.45	0.73	0.28	1.35
In.	2.77	1.18	0.88	0.75	0.69	3.12	1.21	0.66	0.50	0.84	0.32	1.51

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 2002 - 2010, BY WATER YEAR (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	98.7	61.1	51.1	37.2	31.3	104	291	119	48.8	32.2	22.9	35.0
Max	246	90.9	79.8	67.6	55.6	175	522	258	90.7	60.0	59.0	87.5
(WY)	(2008)	(2006)	(2008)	(2008)	(2006)	(2010)	(2002)	(2003)	(2004)	(2004)	(2009)	(2010)
Min	22.4	25.6	20.6	14.3	21.2	34.0	70.0	36.9	21.2	8.96	5.76	11.5
(WY)	(2009)	(2007)	(2009)	(2009)	(2009)	(2008)	(2010)	(2010)	(2007)	(2007)	(2007)	(2006)

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

SUMMARY STATISTICS

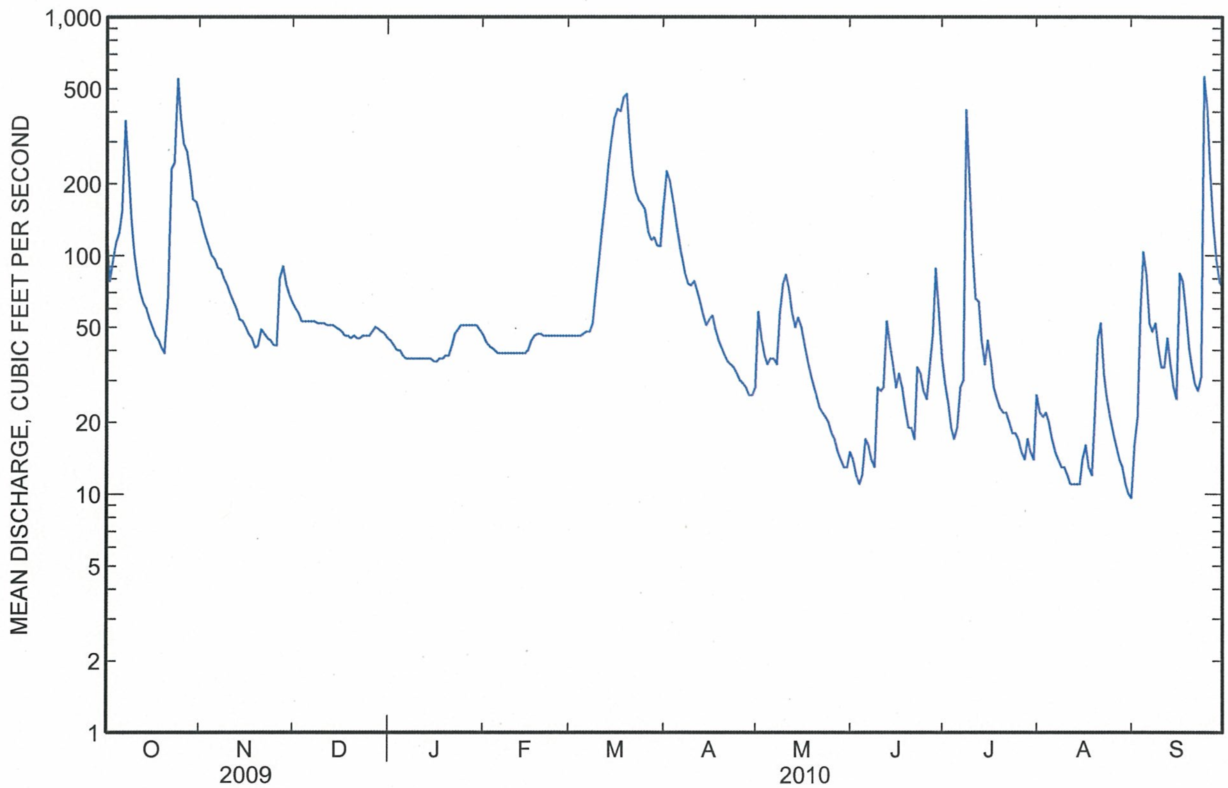
	Calendar Year 2009		Water Year 2010		Water Years 2002 - 2010	
Annual total	28,325.0		25,088.6			
Annual mean	77.6		68.7		77.7	
Highest annual mean					99.1	2003
Lowest annual mean					52.0	2007
Highest daily mean	1,100	Apr 25	559	Sep 24	2,660	May 12, 2003
Lowest daily mean	9.2	Sep 25	9.6	Aug 31	4.0	Aug 17, 2007
Annual seven-day minimum	9.7	Sep 21	12	Aug 8	4.2	Aug 14, 2007
Maximum peak flow			[a]679	Sep 24	[b]3,180	May 12, 2003
Maximum peak stage			[c]9.04	Mar 12	15.18	May 12, 2003
Instantaneous low flow			9.1	Aug 31	3.5	Aug 9, 2007[d]
Annual runoff (cfsm)	1.20		1.06		1.20	
Annual runoff (inches)	16.29		14.42		16.33	
10 percent exceeds	175		146		160	
50 percent exceeds	42		46		38	
90 percent exceeds	13		17		13	

[a] Gage height 8.94 ft.

[b] Result of dam failure.

[c] Backwater from ice.

[d] Also occurred Aug. 11, 14, 15, 17, 18, 2007.



04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Water years 2002 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 2005 to current year (not operated during winter months).
WATER TEMPERATURE: May 2002 to current year (beginning 2006, not operated during winter months).

INSTRUMENTATION.--Water-quality monitor telemeter, set for one-hour measurement interval.

REMARKS.--Specific conductance records rated excellent except for the following periods: Oct. 11-22, Mar. 23 to Apr. 25, , rated good; Oct. 23-31, Apr. 26 to May 11, July 21 to Aug. 10, Sept. 22-31, rated fair; Oct. 1, Nov. 1-25, rated poor. Records were not published Apr. 8-30, May 7-11, Aug. 25, 26, when the maximum allowable limits for reporting were exceeded. Water temperature records rated excellent.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum, 209 microsiemens, Aug. 28, 2007; minimum, 27 microsiemens, Apr. 23, 2008.
WATER TEMPERATURE: Maximum, 27.7°C, July 25, 2007; minimum, -0.5°C, on many days during winter period in 2004 water year.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum, 179 microsiemens, Sept. 01; minimum, 37 microsiemens, Mar. 19, 20.
WATER TEMPERATURE: Maximum, 26.1°C, August 21; minimum, 0.0°C, Nov. 18.

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		October			November			December			January	
1	62	56	59	80	77	78	---	---	---	---	---	---
2	---	---	---	83	80	81	---	---	---	---	---	---
3	---	---	---	83	82	83	---	---	---	---	---	---
4	---	---	---	83	81	82	---	---	---	---	---	---
5	---	---	---	87	83	85	---	---	---	---	---	---
6	---	---	---	92	87	90	---	---	---	---	---	---
7	71	54	59	100	92	96	---	---	---	---	---	---
8	57	53	54	106	100	103	---	---	---	---	---	---
9	63	57	60	109	105	107	---	---	---	---	---	---
10	68	63	66	109	101	106	---	---	---	---	---	---
11	72	68	71	101	95	97	---	---	---	---	---	---
12	75	71	73	99	95	97	---	---	---	---	---	---
13	77	75	76	102	99	101	---	---	---	---	---	---
14	78	75	76	105	100	102	---	---	---	---	---	---
15	79	77	78	106	102	103	---	---	---	---	---	---
16	80	78	79	106	102	104	---	---	---	---	---	---
17	82	80	81	107	105	106	---	---	---	---	---	---
18	84	81	83	110	107	109	---	---	---	---	---	---
19	86	82	84	114	110	112	---	---	---	---	---	---
20	86	84	85	117	114	116	---	---	---	---	---	---
21	88	85	87	117	115	116	---	---	---	---	---	---
22	86	68	77	115	114	115	---	---	---	---	---	---
23	68	63	65	117	115	116	---	---	---	---	---	---
24	70	65	67	119	108	117	---	---	---	---	---	---
25	66	63	64	108	98	101	---	---	---	---	---	---
26	67	64	65	---	---	---	---	---	---	---	---	---
27	67	63	64	---	---	---	---	---	---	---	---	---
28	67	64	65	---	---	---	---	---	---	---	---	---
29	72	67	69	---	---	---	---	---	---	---	---	---
30	76	72	74	---	---	---	---	---	---	---	---	---
31	78	75	77	---	---	---	---	---	---	---	---	---
Month	---	---	---	---	---	---	---	---	---	---	---	---

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	47	42	44	102	100	101
2	---	---	---	---	---	---	44	42	43	101	99	100
3	---	---	---	---	---	---	48	44	46	103	100	101
4	---	---	---	---	---	---	49	47	48	107	102	104
5	---	---	---	---	---	---	53	49	52	106	103	105
6	---	---	---	---	---	---	59	53	57	104	96	100
7	---	---	---	---	---	---	60	58	59	102	99	101
8	---	---	---	---	---	---	60	58	59	99	92	95
9	---	---	---	97	89	93	62	60	61	92	84	87
10	---	---	---	89	80	84	63	61	62	84	78	80
11	---	---	---	80	66	73	61	59	60	85	76	78
12	---	---	---	66	40	56	62	59	60	82	79	80
13	---	---	---	49	43	47	65	61	64	87	82	84
14	---	---	---	44	42	43	66	63	64	89	87	88
15	---	---	---	44	42	42	69	66	67	88	87	88
16	---	---	---	42	40	41	68	66	67	92	88	89
17	---	---	---	42	40	41	67	64	65	96	92	93
18	---	---	---	40	38	39	70	67	68	101	96	98
19	---	---	---	38	37	37	71	68	69	106	101	102
20	---	---	---	41	37	40	73	70	71	110	106	107
21	---	---	---	45	39	42	73	72	73	114	109	111
22	---	---	---	46	42	44	75	72	73	118	113	115
23	---	---	---	48	46	46	77	74	75	123	116	119
24	---	---	---	48	47	48	80	77	78	129	122	125
25	---	---	---	48	47	48	84	80	81	133	128	130
26	---	---	---	51	47	49	88	83	86	140	131	135
27	---	---	---	51	48	50	91	87	88	142	139	141
28	---	---	---	51	51	51	96	91	93	151	141	147
29	---	---	---	52	51	51	100	95	97	148	136	143
30	---	---	---	54	52	53	101	97	99	147	141	143
31	---	---	---	53	47	50	---	---	---	147	143	145
Month	---	---	---	---	---	---	101	42	68	151	76	108

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

SPECIFIC CONDUCTANCE, WATER, UNFILTERED, MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	146	143	145	98	90	93	146	139	143	179	162	170
2	149	145	147	105	98	101	143	140	141	163	128	151
3	152	149	150	114	105	109	144	141	143	142	102	117
4	---	---	---	120	114	117	144	141	142	102	74	84
5	---	---	---	125	119	122	146	142	144	76	68	71
6	---	---	---	130	125	127	151	145	148	88	76	81
7	---	---	---	129	116	123	153	150	151	95	87	90
8	---	---	---	116	40	50	157	153	155	96	88	91
9	---	---	---	56	40	48	162	157	159	89	87	88
10	127	119	121	67	56	60	---	---	---	97	89	93
11	123	119	121	76	67	70	---	---	---	104	97	99
12	123	106	112	91	76	82	---	---	---	104	99	101
13	106	104	105	96	90	91	---	---	---	99	95	96
14	108	105	106	100	96	97	---	---	---	103	97	100
15	113	108	111	107	99	102	---	---	---	106	102	104
16	114	111	113	108	101	104	---	---	---	114	91	102
17	119	114	116	110	103	105	---	---	---	91	79	83
18	124	118	120	115	107	110	---	---	---	86	80	83
19	129	124	126	121	113	116	---	---	---	94	86	89
20	134	129	131	126	120	122	---	---	---	98	91	95
21	135	133	134	129	125	126	132	124	127	105	97	100
22	138	116	126	132	127	129	126	123	124	110	105	107
23	116	105	111	138	131	134	131	125	127	114	108	110
24	108	106	107	139	136	137	138	131	134	115	65	78
25	109	107	108	145	138	140	142	135	139	67	62	65
26	112	109	110	147	142	145	147	141	144	75	62	68
27	111	93	108	150	146	148	152	147	149	82	75	78
28	93	83	86	150	147	149	157	152	154	87	82	84
29	84	82	84	150	148	148	162	157	158	93	87	90
30	91	84	87	154	149	151	167	161	163	96	93	95
31	---	---	---	154	145	151	172	166	167	---	---	---
Month	---	---	---	154	40	113	---	---	---	179	62	95

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		October			November			December			January	
1	8.4	6.2	7.3	5.9	4.9	5.5	---	---	---	---	---	---
2	8.1	7.1	7.7	6.2	5.3	5.8	---	---	---	---	---	---
3	8.9	7.8	8.3	5.3	3.5	4.4	---	---	---	---	---	---
4	9.5	8.7	9.0	4.0	3.0	3.5	---	---	---	---	---	---
5	9.9	8.9	9.3	4.1	2.9	3.7	---	---	---	---	---	---
6	9.2	8.3	8.6	4.4	2.3	3.2	---	---	---	---	---	---
7	8.6	7.8	8.2	6.1	4.4	5.2	---	---	---	---	---	---
8	8.4	7.7	8.2	5.1	3.7	4.3	---	---	---	---	---	---
9	7.9	6.6	7.2	5.4	4.5	4.9	---	---	---	---	---	---
10	6.6	4.5	5.5	4.6	2.9	3.5	---	---	---	---	---	---
11	4.6	3.8	4.2	4.0	2.2	3.1	---	---	---	---	---	---
12	3.8	3.0	3.5	4.9	3.7	4.3	---	---	---	---	---	---
13	4.3	2.9	3.6	5.9	4.7	5.2	---	---	---	---	---	---
14	3.9	2.2	3.1	6.4	5.9	6.1	---	---	---	---	---	---
15	4.4	3.4	3.9	6.2	3.9	5.1	---	---	---	---	---	---
16	4.0	2.8	3.5	3.9	2.0	2.7	---	---	---	---	---	---
17	4.3	3.1	3.8	2.3	0.6	1.3	---	---	---	---	---	---
18	5.4	2.8	4.0	1.3	0.0	0.7	---	---	---	---	---	---
19	7.5	5.2	6.2	3.3	1.2	2.1	---	---	---	---	---	---
20	7.4	6.8	7.0	4.8	3.3	4.0	---	---	---	---	---	---
21	7.0	5.8	6.5	4.0	2.2	2.9	---	---	---	---	---	---
22	5.8	4.7	5.3	5.1	2.5	3.5	---	---	---	---	---	---
23	4.7	4.3	4.5	6.3	5.1	5.8	---	---	---	---	---	---
24	4.6	3.5	3.8	6.2	5.7	5.9	---	---	---	---	---	---
25	4.0	3.0	3.5	5.8	5.5	5.7	---	---	---	---	---	---
26	5.2	4.0	4.5	5.8	3.1	4.7	---	---	---	---	---	---
27	5.8	4.8	5.3	3.1	2.2	2.5	---	---	---	---	---	---
28	5.3	3.7	4.6	2.2	1.3	1.8	---	---	---	---	---	---
29	7.2	4.9	5.9	2.3	1.9	2.1	---	---	---	---	---	---
30	9.8	7.2	8.5	2.1	1.8	1.9	---	---	---	---	---	---
31	8.9	5.9	7.1	---	---	---	---	---	---	---	---	---
Month	9.9	2.2	5.9	6.4	0.0	3.8	---	---	---	---	---	---

04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		February			March			April			May	
1	---	---	---	---	---	---	9.1	6.3	7.9	16.4	12.3	14.2
2	---	---	---	---	---	---	12.3	8.0	10.2	16.0	12.2	14.1
3	---	---	---	---	---	---	12.3	9.1	11.1	14.4	11.5	12.4
4	---	---	---	---	---	---	9.1	7.2	8.0	14.3	10.3	12.1
5	---	---	---	---	---	---	10.3	6.6	8.3	13.0	11.1	12.2
6	---	---	---	---	---	---	9.2	7.6	8.5	13.0	9.7	11.3
7	---	---	---	---	---	---	8.7	6.3	7.5	11.3	6.8	8.6
8	---	---	---	---	---	---	6.9	3.9	5.1	8.4	5.3	6.8
9	---	---	---	---	---	---	6.6	2.5	4.4	9.4	4.7	7.1
10	---	---	---	---	---	---	8.8	4.5	6.4	10.9	5.5	8.3
11	---	---	---	---	---	---	9.3	5.2	7.2	9.8	8.5	9.1
12	---	---	---	---	---	---	9.5	6.5	8.0	13.0	7.9	10.3
13	---	---	---	---	---	---	8.5	6.4	7.6	11.7	9.9	10.2
14	---	---	---	---	---	---	12.2	7.6	9.8	9.9	8.9	9.6
15	---	---	---	---	---	---	14.2	11.5	12.6	13.4	7.4	10.4
16	---	---	---	---	---	---	13.2	8.2	10.4	15.9	9.7	12.9
17	---	---	---	---	---	---	8.5	6.1	7.3	17.1	12.0	14.6
18	---	---	---	---	---	---	10.2	5.7	7.8	17.4	12.0	14.8
19	---	---	---	---	---	---	10.0	6.0	8.1	18.8	12.9	15.8
20	---	---	---	---	---	---	11.7	6.8	9.2	18.8	13.9	16.3
21	---	---	---	---	---	---	10.3	5.7	7.6	16.9	13.7	15.6
22	---	---	---	---	---	---	8.7	3.5	6.1	16.7	14.3	15.4
23	---	---	---	---	---	---	11.2	5.4	8.4	20.6	15.2	17.7
24	---	---	---	---	---	---	11.5	8.8	10.3	24.2	18.7	21.2
25	---	---	---	---	---	---	12.6	8.5	10.4	24.7	21.3	22.9
26	---	---	---	---	---	---	11.9	7.7	9.8	23.2	20.0	21.6
27	---	---	---	---	---	---	11.5	7.0	9.2	22.1	17.1	19.4
28	---	---	---	---	---	---	11.7	6.3	9.0	21.3	15.9	18.4
29	---	---	---	---	---	---	10.7	8.2	9.7	21.8	15.8	18.5
30	---	---	---	---	---	---	13.4	9.6	11.5	22.4	16.9	19.3
31	---	---	---	---	---	---	---	---	---	22.8	18.4	20.1
Month	---	---	---	---	---	---	14.2	2.5	8.6	24.7	4.7	14.2

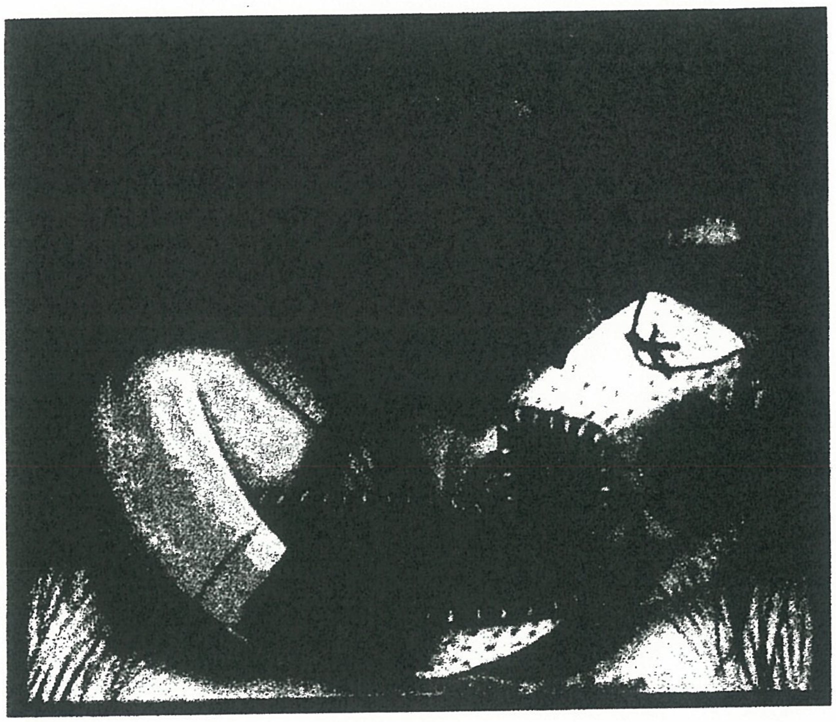
04043150 SILVER RIVER NEAR L'ANSE, MI—Continued

TEMPERATURE, WATER, DEGREES CELSIUS
WATER YEAR OCTOBER 2009 TO SEPTEMBER 2010

Day	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
		June			July			August			September	
1	22.3	17.3	19.6	16.9	13.6	15.0	22.5	18.5	20.4	22.6	20.0	21.6
2	20.5	17.3	18.8	21.6	15.4	18.2	22.4	20.6	21.4	20.0	16.9	17.9
3	20.7	14.8	17.6	24.8	19.2	21.7	24.8	20.5	22.3	17.4	14.0	16.0
4	17.6	---	16.5	24.4	22.0	23.2	24.3	21.2	22.6	14.0	12.5	13.0
5	---	---	---	23.6	21.3	22.4	22.6	20.3	21.4	14.1	10.9	12.5
6	---	---	---	23.7	20.6	22.0	21.7	18.0	19.7	15.1	11.7	13.2
7	---	---	---	24.3	20.4	22.3	21.4	16.8	19.0	15.0	13.6	14.5
8	---	---	---	22.3	19.1	20.1	23.5	19.0	20.9	13.6	12.3	12.8
9	15.8	---	---	21.7	18.6	20.0	24.8	19.7	21.9	13.0	10.9	12.0
10	16.3	13.3	14.7	22.2	17.8	20.0	25.1	20.1	22.4	13.5	10.1	11.9
11	15.4	13.6	14.5	21.1	19.9	20.4	24.0	21.6	22.6	13.5	12.7	13.2
12	14.4	12.9	13.7	21.6	18.2	19.9	26.1	21.4	23.4	14.6	12.2	13.3
13	15.7	13.6	14.7	20.6	16.6	18.9	25.9	22.3	23.8	14.2	12.2	13.2
14	18.4	14.4	16.2	19.8	18.1	18.9	26.0	21.4	23.4	13.4	11.4	12.4
15	17.4	15.4	16.0	22.6	18.5	20.3	24.0	19.7	21.7	12.4	9.6	10.8
16	16.7	14.7	15.6	23.3	19.2	21.2	20.0	17.7	18.9	12.2	10.7	11.3
17	19.0	14.1	16.7	23.4	19.6	21.5	19.9	16.4	17.8	11.6	10.3	10.9
18	22.6	18.0	20.1	21.6	19.5	20.5	18.4	16.6	17.5	12.2	10.8	11.4
19	21.2	18.4	19.3	22.8	19.1	20.7	19.9	16.1	17.6	11.1	8.7	10
20	21.6	16.6	18.8	21.2	19.5	20.4	18.0	16.8	17.6	11.0	7.8	9.4
21	20.6	16.7	18.8	22.7	17.9	20.0	19.2	17.4	18.1	14.7	11.0	13.0
22	21.0	18.0	19.6	20.6	18.6	19.4	20.2	16.3	18.2	13.7	11.0	12.2
23	20.4	18.5	19.2	21.9	18.3	19.7	21.0	16.4	18.7	12.7	12.0	12.4
24	21.2	17.6	19.2	20.2	18.7	19.3	20.2	18.6	19.7	13.8	12.4	13.2
25	19.7	17.7	18.3	22.5	17.1	19.5	18.7	16.3	17.6	12.4	10.4	11.3
26	20.7	17.0	18.6	23.4	18.2	20.6	18.6	14.3	16.2	10.5	8.5	9.6
27	19.7	17.6	18.6	23.4	20.3	21.8	20.3	14.8	17.2	11.1	8.8	9.9
28	18.7	16.8	17.7	24.0	20.8	22.2	22.2	17.9	19.6	11.0	10.7	10.9
29	17.9	14.6	16.2	23.4	19.1	21.2	23.0	18.8	20.6	12.1	10.0	11.0
30	18.2	13.4	15.8	23.0	19.1	21.0	24.9	20.2	22.3	12.2	10.7	11.4
31	---	---	---	21.4	19.9	20.6	23.6	21.6	22.7	---	---	---
Month	---	---	---	24.8	13.6	20.4	26.1	14.3	20.2	22.6	7.8	12.5

WATER RESOURCES OF THE KEWEENAW BAY INDIAN COMMUNITY, BARAGA COUNTY, MICHIGAN

U.S. Department of the Interior
U.S. Geological Survey
Water-Resources Investigations Report 98-4060



Prepared in cooperation with the
KEWEENAW BAY INDIAN COMMUNITY

Keweenaw Bay
Indian Community

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WATER RESOURCES OF THE KEWEENAW BAY INDIAN COMMUNITY, BARAGA COUNTY, MICHIGAN

by M.J. Sweat and S.J. Rheaume

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 98-4060

Prepared in cooperation with the
KEWEENAW BAY INDIAN COMMUNITY

Lansing, Michigan
1998

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ILLUSTRATIONS

TABLES

CONVERSION FACTORS, ABBREVIATED WATER QUALITY UNITS, AND VERTICAL DATUM

Multiply	By	To Obtain
	Length	
millimeter (mm)	0.03937	inch
centimeter (cm)	.3937	inch
meter (m)	3.281	foot
	Area	
square kilometer (km^2)	247.1	acre
hectare (ha)	2.471	acre
square meter (m^2)	10.76	square foot
square kilometer (km^2)	.3861	square mile
hectare	.003861	square mile
	Volume	
liter (L)	.2642	gallon
cubic meter (m^3)	264.2	gallon
milliliters (ml)	.0002642	gallon
cubic meter	35.31	cubic foot
	Flow (volume per unit time)	
millimeter per year (mm)	.0394	inch per year
meter per second (m/s)	3.281	foot per second
cubic meter per second (m^3/s)	35.31	cubic foot per second
liter per second (L/s)	.03531	cubic foot per second
liter per second	15.85	gallon per minute
cubic meters per second	22.82	million gallons per day
	Transmissivity	
meter squared per day	10.76	foot squared per day
	Temperature	

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by use of the following equation:

$$°F = (1.8 \times °C) + 32$$

Abbreviated water-quality units

Chemical concentrations are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) and micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as a weight (milligrams) of solute per unit volume (liter) of water. Likewise, micrograms per liter is a unit expressing the concentration of chemical constituents in solution as a weight (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Turbidity is a measure of opaqueness or reduced clarity of water, and is expressed in nephelometric turbidity units (NTU). Nephelometric turbidity units are a measure of the intensity of light scattered in one particular direction, predominantly at right angles to the incident light.

Specific conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

Tritium concentration (or activity) in water is expressed as picoCuries per liter (pCi/L).

Vertical Datum

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Water Resources of the Keweenaw Bay Indian Community, Baraga County, Michigan

by M.J. Sweat and S.J. Rheaume

ABSTRACT

The Keweenaw Bay Indian Community (KBIC) in Baraga County uses ground water for most domestic, commercial, and industrial supplies. An industrial park within KBIC could adversely affect some ground-water supplies should contaminants be spilled at the park. Additional development of the park is being planned. Information on water supply potential and aquifer vulnerability to contamination is needed to make sound decisions about future activities at the industrial park.

Unconsolidated glacial deposits overlie bedrock within the Keweenaw Bay Indian Community. Usable amounts of ground water are withdrawn from the glacial deposits only in isolated areas. Principal aquifers are the Jacobsville Sandstone and the Michigamme Slate. Aquifer test and water level data from these principal aquifers indicate that they are confined and hydraulically connected throughout most of KBIC.

Ground water generally flows toward Keweenaw and Huron Bays and the Silver River. Between the industrial park and Keweenaw Bay, ground water flows to the southeast, toward the Bay. Along this flow path in the bedrock, glacial deposits are generally thicker than 25 meters, and contain thick lenses of clay and clay mixed with sand. The average depth to ground water along this flow path is greater than 25 meters, indicating unconfined conditions. Near the shore of Keweenaw and Huron Bays, however, and at isolated areas throughout KBIC, water levels in wells are above land surface.

Analyses of water samples collected in 1991 and 1997 indicate that the quality of ground water and surface water is suitable for most domestic, commercial, and industrial uses. However, U.S. Environmental Protection Agency secondary maximum contaminant limits for dissolved iron and manganese were exceeded in 4 and 5 wells, respectively, which may make the water from these wells unsuitable for some uses. Concentrations of lead in water from one well was above the maximum contaminant limit.

Concentrations of tritium in ground water downgradient from the industrial park indicate that at least some recharge to the Jacobsville Sandstone has taken place within the last 45 years. Where clay lenses greater than 1 meter thick overlie the glacial aquifer or the Jacobsville Sandstone, however, recharge may take longer than 45 years.

A contaminant spill at the industrial park would likely move laterally, toward Keweenaw Bay, in the glacial aquifer. Some infiltration does occur through the glacial aquifer to the bedrock aquifers. No information is available concerning the rate of movement of water within this aquifer, so it is not possible to determine the rate at which a spill would move either vertically or laterally within the glacial aquifer toward either Keweenaw Bay or the Jacobsville Sandstone.

Increased pumping from the existing well at the industrial park, or the development of additional wells, could potentially lower water levels in the Jacobsville Sandstone in the area of the park. Sufficient lowering of water levels could create unconfined conditions in the Jacobsville Sandstone, thereby increasing the susceptability of the aquifer to contamination.

INTRODUCTION

The Keweenaw Bay Indian Community (KBIC) is concerned about the possibility of deteriorating water quality in the Keweenaw Bay area in Michigan's Upper Peninsula. Changes in water quality could affect water supplies and plans for future development. The development of a 105-hectare industrial park in the western part of KBIC has the potential to affect both the quantity and quality of water supplies. Doonan and others (1970) studied ground-water resources of the Keweenaw Peninsula, and Doonan and Byerlay (1973) studied ground-water resources of Baraga County. However, detailed studies of the relation of geology, hydrology, and land use to surface and ground-water quality in the KBIC have not been made. Strategies for the protection of water resources cannot be developed until these relations are better understood. The investigation described here was conducted as a cooperative effort between KBIC and the U.S. Geological Survey (USGS) to address these information needs.

Purpose and Scope

This report describes the results of a study of the physical and chemical characteristics of ground and surface-water resources of KBIC, and relates these characteristics to geology, hydrology, and land use. The report is based on data collected in 1991 and 1997, and provides information that will be useful to water-resource planners and managers in developing strategies for water-quality protection and water-supply development. Results of chemical analyses of water samples from wells, streams, and the Assinins Wetland are included in tables at the back of the report.

Methods of Investigation

In 1991, work focused on evaluating the water quality of streams tributary to Keweenaw Bay and of the ground-water system. Water samples collected from 11 tributaries, 2 wetland ponds, and 11 wells were analyzed in the laboratory for common dissolved substances, trace metals, nutrients, bacteria, phenols, and volatile organic compounds. Temperature, pH, specific conductance, dissolved oxygen, and alkalinity were measured in the field. Streambed sediment samples were collected from selected sites for analysis of pesticides and trace metals.

In July 1997, 8 of the 11 previously sampled wells were resampled for analysis of common dissolved substances, trace metals, and nutrients. Temperature, pH, specific conductance, and alkalinity were measured in the field. Two additional wells were sampled, one in the industrial park and one near to, and similar in depth and construction, to a well sampled in 1991 that had been removed from service.

The relation of well hydraulics to the ability of the aquifer to produce water was analyzed using the results of pump tests, well capacity tests, drill logs, and maps. Local areas of ground-water discharge and recharge are tentatively identified. Where sufficient data exist, probable ground-water flow paths are identified, and their relation to water production is described. Results of field and laboratory analyses of ground-water samples were examined using graphical methods, and are presented in this report. An analysis of the surface-water and wetlands water-quality data is also presented.

Acknowledgments

Field work in 1991 was done with the assistance of Howard Reynolds, then the KBIC Environmental Coordinator, and Michael Donofrio, KBIC Fisheries Biologist. The sample and data collection in 1997 was made possible by the assistance of F. William Beaver, KBIC Geographic Information Systems (GIS) Coordinator. Stephen Aichele and F. William Beaver provided many of the GIS coverages used in illustrations for this report. Many KBIC, County, and local officials, as well as citizens, provided data, access to property and wells, and took an active interest in the project.

GENERAL DESCRIPTION OF STUDY AREA

Keweenaw Bay Indian Community is in Baraga County in the northwestern part of Michigan's Upper Peninsula, near the southern terminus of Keweenaw Bay (fig. 1). The study area comprises lands under the jurisdiction of KBIC. The land surface is generally hilly and ranges in elevation from 183 m at Keweenaw Bay to about 565 m in the southeastern part of the study area (fig. 2), with steep slopes rising from near the Keweenaw Bay shore.

The study area comprises about 290 km^2, of which about 45 km^2 is covered by Keweenaw Bay. Most of the land is forested with only a small percent of the area used for agriculture, primarily beef and dairy production. Logging, manufacturing, and tourism are the principal contributors to the economy. The 1990 population of the study area was estimated at about 6,000. The two largest communities are L'Anse and Baraga (fig. 1), with 1990 populations of about 2,500 and 1,055 respectively (U.S. Bureau of Census, 1992).

Climate at KBIC is moderated by Lake Superior and the Keweenaw Peninsula.

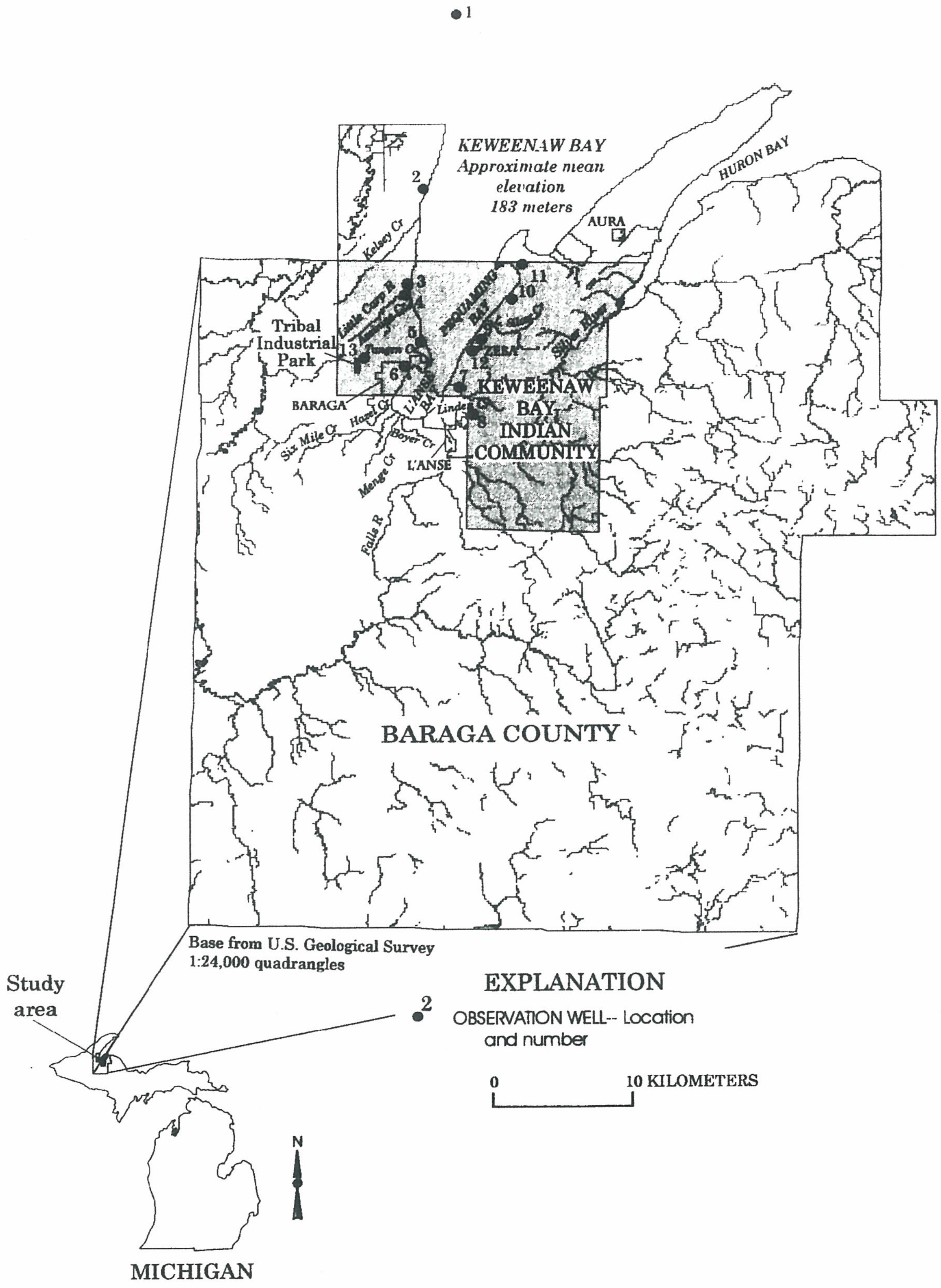

Figure 1. Location of the Keweenaw Bay Indian Community study area and location of ground-water sampling sites.

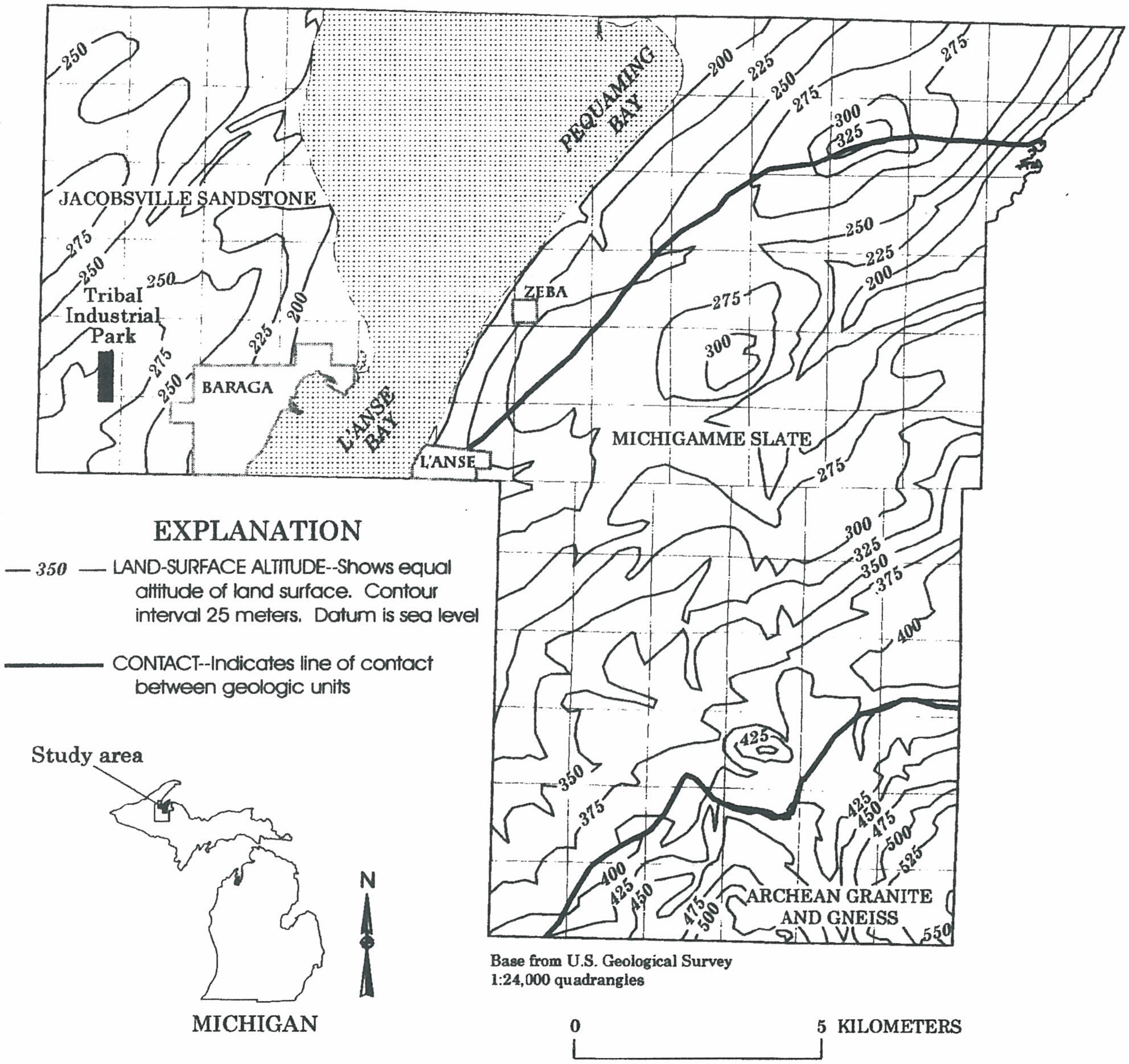

Figure 2. Elevation of land surface and approximate contact between geologic units within the study area. (Geology from Reed and Daniels, 1987.)

Precipitation is influenced by the location of Keweenaw Bay, and tends to increase predominantly in the downwind direction, (southeast and east) from the Bay. Average annual precipitation is about 100 cm per year. Average rainfall is about 57 cm; average annual snowfall is about 365 cm. Extreme temperatures range from about -40 °C to about 32°C; mean monthly temperatures range from about -11 °C to about 17 °C (National Oceanic and Atmospheric Administration, 1997, pp. 2-3, 8, 11).

GEOLOGIC SETTING

The geology of the Keweenaw Bay Indian Community consists of unconsolidated alluvial and glacial deposits of Pleistocene age and consolidated strata of Keweenawan, early Proterozoic, and Archean age. The general lithologic characteristics of these deposits are described below. Specific lithologic data were obtained from well logs on file with the Indian Health Service and with the Michigan Department of Public Health.

Alluvium

Alluvium in the study area consists of sand, gravel, and clay reworked from glacial till and lakebed deposits; peat bogs; and marl deposits. Generally, these deposits are thin and probably contain some glacial outwash material at depth. Most areas of alluvium are too small to map.

Glacial Deposits

During the Wisconsin Stage glaciation, the entire Keweenaw Peninsula was covered by up to 3000 m of ice (Sugden, 1977) and many glacial features are apparent in the study area. Depositional features include various types of moraines. Hughes (1963) estimated that 80 percent of the Keweenaw Peninsula is covered by hummocky, boulder-rich glacial sediments deposited as ground moraine. Glacier-related deposits of water-laid origin are described by Regis (1993) and include outwash, eskers, deltas, kames, and channel deposits.

In the study area, glacial deposits are primarily a yellow and brown to reddish boulder clay or till, lake clay, or sand. Some coarse-grained outwash also occurs. Most of the deposits are thin and locally are absent in areas of bedrock outcrops. The deposits range in thickness from a few millimeters to several tens of meters, however, and stratified lake sand from 60 to 90 m thick, with seams of lake clay, is reported in the Six Mile Creek and Pequaming Bay areas.

Bedrock

Intrusive and metamorphic bedrock units in the study area were deposited between 1100 and 1000 million years ago (Ma) as part of the Midcontinent rift system of North America (Bornhorst and Rose, 1994, p. 10.) These granitic and gneissic rocks underlie younger metamorphic and sedimentary deposits of slate and sandstone throughout the study area, but are too deeply buried in all but the southeast part of the study area to be used as aquifers. These rocks are the oldest, and topographically highest rocks in the study area. They consist of schistose and gneissic intrusives, and contain masses of syenite schist, hornblende-rich gneiss, and massive granite. They are the uppermost bedrock unit only in the extreme southeast part of the study area.

The Michigamme Slate is the uppermost bedrock unit throughout most of the eastern half of the study area, with the exception previously noted, and in the area northeast of Pequaming Bay, where it is not present because of erosion. It consists of dark quartz slate to graphitic slate and graywacke, mica schist and gneiss, and quartzite locally recrystallized as schist. Ferruginous beds of iron ore, conglomerate, and chert are common. The Michigamme Slate may be as much as a few hundred meters thick.

The Jacobsville Sandstone is the uppermost bedrock unit throughout the western half of the study area, and along the southeastern shore of Keweenaw Bay, south of Pequaming Bay, from about Zeba southwestward, and from Pequaming Bay northeast toward Huron Bay. It consists of a light-red to brown quartz sandstone with beds of red arkosic sandstone, red micaceous sandy shale, and conglomerate, and is in unconformable contact with the underlying Michigamme Slate. Its thickness ranges from about 300 m in the northwest part of the study area to less than 1 mm where it pinches out at the south end of Keweenaw Bay. The Jacobsville Sandstone is exposed in cliffs along most of Keweenaw Bay's shoreline.

GEOHYDROLOGY

The Little Carp, the Falls, and the Silver Rivers are the principal streams in the Keweenaw Bay Indian Community, and about 160 lakes and ponds have been mapped. About 42 percent of the 100 cm of annual precipitation runs off to the streams (Blumer and others, 1997, p. 43-44); of the remainder, most either evaporates or is transpired by plants, and some recharges the ground water. The streams in KBIC ultimately drain to the southern parts of either Keweenaw or Huron Bays. The communities of Baraga and L'Anse obtain their water supplies from Keweenaw Bay. Glacial deposits provide usable amounts of ground water locally, but the principal aquifers in the KBIC are the bedrock units.

Ground Water

Ground water is the principal source of drinking water for most households in the KBIC, and for most industrial and agricultural uses. The Jacobsville Sandstone and the Michigamme Slate are the principal aquifers in the study area, and they supply most of the domestic and commercial wells in the study area. Wells on the west side of Keweenaw Bay are typically completed in the Jacobsville Sandstone. On the east side of the Bay, wells near the shore are completed in either the Jacobsville Sandstone or unconsolidated surficial deposits. Inland from the Bay, wells are typically completed in the Michigamme Slate or, in the extreme southeastern part of the study area, in Archean granite or gneiss.

Glacial aquifers

Glacial deposits are a source of water in two small areas (fig. 3), one in the west-southwest part of the KBIC, and another just south of Pequaming Bay, in the north-central part. In most of the area, the glacial deposits form a semi-confining unit on top of the underlying bedrock, and they are locally thin or absent.

Water-supply wells completed in the glacial deposits are generally greater than 30 m deep, although they may be as shallow as 10 m. In general, water is withdrawn from lenses of sand and gravel, and wells in these deposits will yield less than 1 L/s (Twenter, 1966b). Locally, wells 15 cm or more in diameter occasionally yield several tens of liters of water per second, especially if the wells are completed in sand and gravel deposits along streams. The maximum reported depth to water in glacial deposits was 67 m (based on water levels in 24 wells, recorded with Indian Health Service and Michigan Department of Public Health between 1967 and 1995); depth to water ranged from 1.5 to 67 m between 1969 and 1997.

Jacobsville Sandstone

The Jacobsville Sandstone is the principal aquifer along Keweenaw Bay. The KBIC industrial park well is completed in the Jacobsville Sandstone, as are most wells that supply water to Tribal housing units. These wells are generally deep, ranging from about 15 to 140 m, although most wells are greater than 60 m deep. Twenter (1966a) and Rheaume (1991) report that wells completed in the Jacobsville Sandstone near the KBIC are likely to yield less than 1 L/s, although wells greater than 15 cm diameter occasionally yield several liters per second. The Jacobsville Sandstone is well cemented and thus has low primary permeability, and Vanlier (1963) reports that most water in nearby Alger County moves along fractures and separations in bedding planes. Wells completed in the Jacobsville Sandstone may produce saline water.

The potentiometric surface in the Jacobsville Sandstone within the KBIC is shown in figure 4. On the west side of Keweenaw Bay the surface rapidly increases in elevation away from the Bay, reaching a ground-water divide along the western edge of the study area. Assuming isotropy in the potentiometric head distribution, flow is generally from the west to the east, toward Keweenaw Bay, and the Little Carp River and then to Keweenaw Bay. Many wells completed in the Jacobsville Sandstone flow at the land surface, particularly near the shoreline of Keweenaw Bay. The water table is at or near land surface along the Little Carp

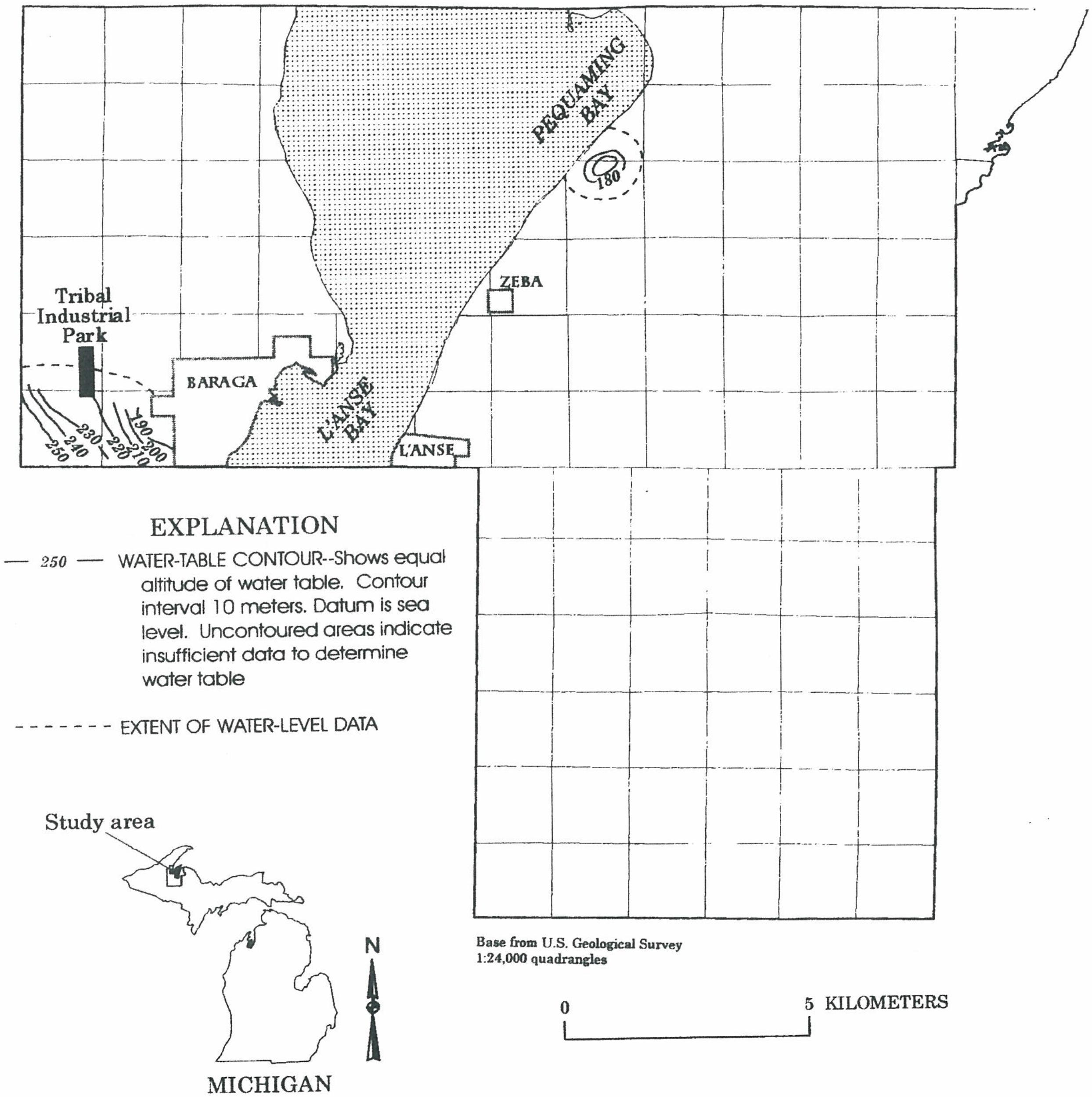

Figure 3. Extent of surficial deposits used as an aquifer, and water-table map (1969-97) in the surficial deposits.

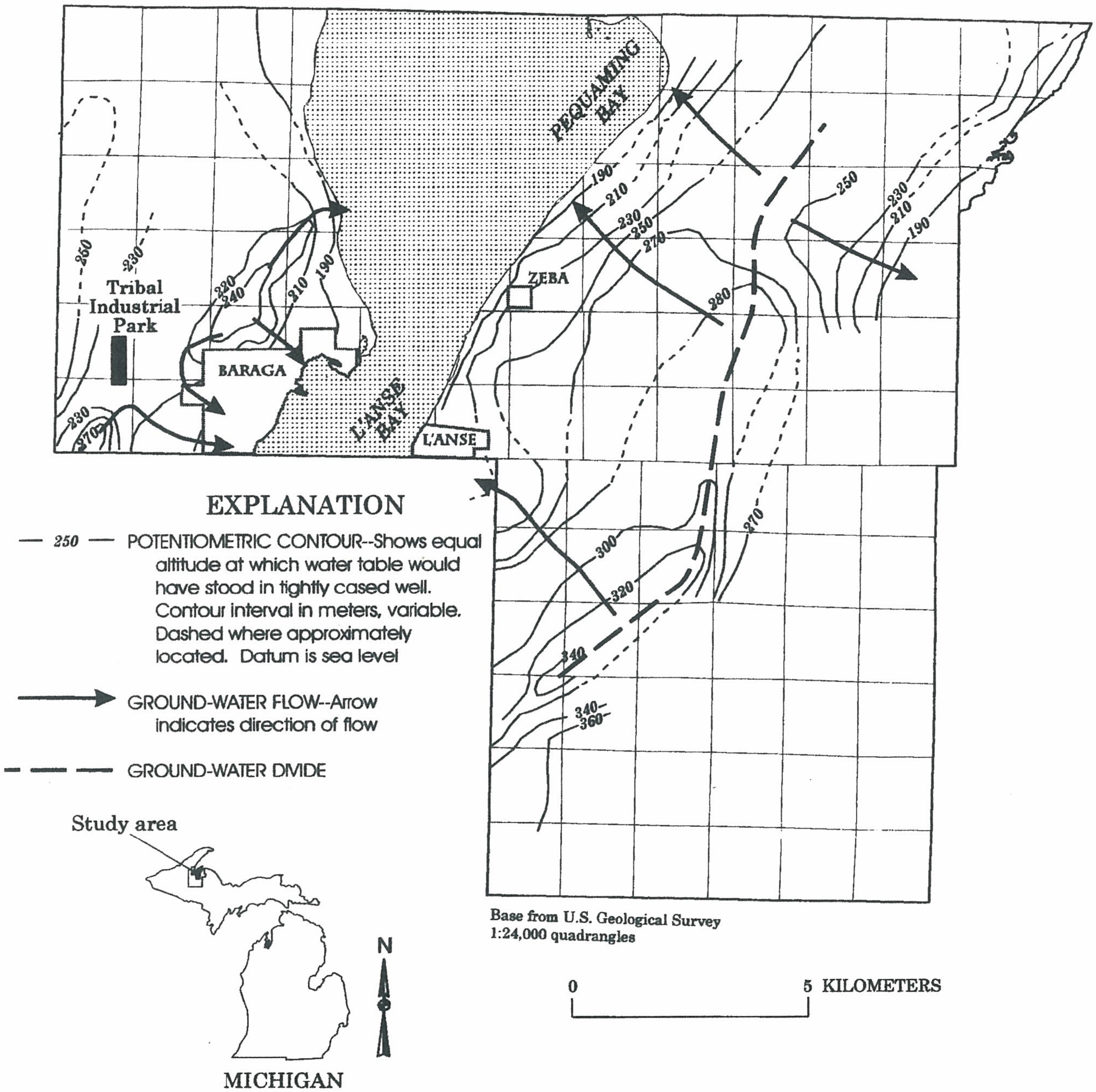

Figure 4. Potentiometric surface in the bedrock formations underlying the Keweenaw Bay Indian Community, and direction of ground-water flow.

River, the Assinins Wetlands, and many areas along the shore of Keweenaw Bay. This indicates that ground-water flow potential has an upward component in this part of the aquifer. The chance of contamination of water in the Jacobsville Sandstone from directly overlying surficial sources is lessened in areas where the potentiometric surface is at or above land surface.

On the east side of Keweenaw Bay, the potentiometric surface increases to the east, reaching a ground-water divide between Keweenaw and Huron Bays. Because wells in this area commonly are completed in both aquifers, and the producing zone of wells is open to both aquifers, the potentiometric surface on the east side of Keweenaw Bay is a combination of the potentiometric surface in both aquifers. Flow is to both sides of the ground-water divide, toward Keweenaw Bay on the west side of the divide and toward the Silver River and Huron Bay on the east side of the divide.

Michigamme Slate

East of Keweenaw Bay and south of Huron Bay, the Michigamme Slate is the principal aquifer where the Jacobsville Sandstone is not present. Wells completed in the Michigamme Slate range in depth from about 15 to 92 m; most wells are between about 45 and 60 m deep. As with wells completed in the overlying Jacobsville Sandstone, reported yields from the Michigamme Slate are generally less than 1 L/s, although some wells greater than 15 cm diameter occasionally yield several liters per second.

Water levels in the Michigamme Slate are similar to those in the Jacobsville Sandstone in certain areas southeast of Pequaming Bay. Figure 4 shows the potentiometric surface of water in the Michigamme Slate where it is used as an aquifer in the study area. The potentiometric surface is near or above land surface along the shore of Keweenaw and Pequaming Bays, and increases rapidly in elevation as distance from the shore increases. Ground-water flow is generally to the northwest toward Keweenaw Bay, except for a small area in the northeastern part of the study area, where flow is to the southeast toward the Silver River and Huron Bay. The direction of ground-water flow could not be determined for the southeastern part of the study area because of a lack of data for this area.

Archean granite and gneiss

Archean granite and gneiss is used as a water-supply aquifer in the southeastern part of the study area; however, only 6 logs were located for wells completed in these rocks. No wells completed in these rocks were sampled for water quality, and no attempt is made to draw inferences about water availability and directions of ground-water flow from the few data available. Wells generally are not drilled to the granite and gneiss where these rocks are overlain by the Michigamme Slate or the Jacobsville Sandstone.

Water table and ground-water flow

Logs for 265 wells completed in the bedrock in the study area were obtained from Indian Health Service and the Michigan Department of Public Health and analyzed to assess head distribution and flow direction within the study area (well locations not shown). Reported water levels for 64 percent (170) of these wells were above the top of the bedrock surface, indicating confined conditions. For the remaining 36 percent (95) of the wells, water levels were below the top of the bedrock, by an average of about 8 m, possibly indicating unconfined conditions. Data from pump tests or drawdown/recovery tests were available for 21 of the wells. The drawdown data were analyzed to determine the storage and hydraulic conductivity of the bedrock. Storage coefficients were generally in the range of 10^{-5}, at the lower end of values reported by Freeze and Cherry (1979, p 60) for confined aquifers; hydraulic conductivities ranged from 10^{-4} to 10^{1} m/d, generally within the range given by Freeze and Cherry (1979, p. 29, table 2.2) for typical sandstone and fractured metamorphic rocks. In general, the aquifers are confined, except north of Baraga, where unconfined conditions exist in 2 areas where bedrock is steeply rising away from Keweenaw Bay.

Directions of ground-water flow in the KBIC can be inferred from a potentiometric map. The map in figure 4 is drawn on the basis of water levels measured between 1969 and 1997, and is a composite of water levels in both the Jacobsville Sandstone and the Michigamme Slate. Ground water flows from high potential elevations to low potential elevations. Assuming that water flows with equal ease in any direction (isotropic conditions), flow is perpendicular to potentiometric contours. The contour information is not sufficiently detailed, however, to determine flow direction at specific locations.

The hydraulic gradient in the study area mimics the contours of the land surface; it is steep near the shore of Keweenaw Bay, under the steep slopes and cliffs leading to the Bay, and shallow away from the shore, under areas of upland highs and broad, flat expanses of land. There are hydraulic divides between Keweenaw Bay and Huron Bay and between Keweenaw Bay and streams draining to the Silver River. In the western part of the study area, there may be a hydraulic divide between Keweenaw Bay and drainage basins west of the study area.

Ground-Water Recharge Rates

Concentrations of tritium, a radioactive hydrogen isotope with atomic mass of 3, increased in rainwater following atomic testing in the atmosphere in 1952-1964 (Michel, 1989). Although tritium does not present a health concern, concentrations of tritium in ground water are used as an indicator of post 1953 recharge. Because tritium has a relatively short radiometric half-life (12.3 years), the concentration of this isotope makes it a useful indicator of ground-water recharge in the last 45 years. If detectable concentrations of tritium (5.7±3.2 pCi/L) are present in water, then some part of that water must have entered the aquifer after 1953. A lack of detectable concentrations of tritium in water, however, is not necessarily indicative of pre-1953 recharge. No significant amounts of tritium have been artificially introduced to the atmosphere since 1964, and the tritium concentrations are declining naturally with the radioactive decay of the isotope.

Tritium concentrations in water sampled in the KBIC in 1997 ranged from <5.7±3.2 to 29.1±3.8 pCi/L. These data are useful for estimating a time period during which recharge occurred. The maximum concentration in water from the Jacobsville Sandstone was 29.1±3.8 pCi/L, at well 6. Using decay-corrected concentrations of tritium in rainwater based on tritium-deposition estimates of Michel (1989), as calculated by Nicholas and others (1994, p 56) for southeast Michigan, it is possible to determine a time period during which this water entered the Jacobsville Sandstone. On the basis of the tritium curve of Nicholas and others (1994), and accounting for different units, water with tritium concentrations between 4.9 and 30.0 pCi/L recharged the aquifers sometime between 1954 and the early 1980's. The reporting limit for tritium analysis is greater than the minimum concentration for which an age determination is possible. Although tritium concentrations in ground water below the detection limit are of indeterminate age, they are more likely to correspond to areas recharged prior to 1954, or after the mid-1980's, than water with higher tritium concentrations.

Results of analyses of 3 of 5 samples from the Jacobsville Sandstone indicate some portion of the water was recharged to the aquifer between 1954 and the early 1980's. For the glacial aquifers, tritium concentrations in 1 of 5 samples indicates some portion of the water was recharged to the aquifer between 1954 and the early 1980's. Generally, glacial aquifers of sand or sand and gravel are more readily recharged than are bedrock aquifers. However, confined or semi-confined layers of sands and gravels in these deposits may not recharge as readily. For example, well 7 is deep (28 m), completed in a gravel and sand aquifer, and is overlain by more than 15 m of clay and mixed clay and sand, which could effectively prevent rapid recharge to the aquifer. Well 8 is shallow (15 m) and completed in sand and slate. The producing zone of this well is overlain by about 4 m of clay. It is also possible that this well is actually completed in the Michigamme Slate, which would not be expected to receive recharge as readily as would an unconsolidated sand aquifer.

Recharge to aquifers in the past 45 years is indicated by ground water with detectable tritium. These aquifers generally are unconfined sand, sand and gravel, and bedrock exposed at the surface or covered by a thin mantle of unconsolidated sediments. Such is the case in well 5, which is a shallow (15 m) well completed in sand, and which has less than one half meter of clay mixed with sand overlying the water-bearing sand. Wells 2, 4, and 6, which are all completed in the Jacobsville Sandstone, and have <4, <1, and <4 m of sand and mixed sand and clay over the bedrock, respectively, also had detectable concentrations of tritium, indicating at least partial recharge in the past 45 years.

Susceptibility to Contamination

The susceptibility of aquifers to contamination is of concern to residents of the KBIC. Contamination can occur from infiltration of materials spilled on the land surface, and by migration of contaminants once they enter ground water. Lusch and others (1992) found that most of the northern part of the study area is overlain by moderately or slowly permeable soils, which would slow the migration of surface contaminants into ground water. Soils in the southern part of the study area are more permeable, however, and thus the ground water here could be more susceptible to contamination. The direction of ground-water flow also influences the susceptibility of the aquifers to contamination. Throughout the study area, flow is lateral, towards Keweenaw and Huron Bays, which would lessen the susceptibility of deep aquifers to contamination. There is also an upward flow potential in the ground-water system in many places, which also lessens the susceptibility of the aquifer to contamination.

Soils over the Jacobsville Sandstone and the Michigamme Slate are only moderately to slowly permeable, and recharge is limited by the capacity of the soils to transmit water. Thus, in areas where the aquifer is deeply buried, the aquifer is less prone to contamination from surface sources than it is in areas where the aquifer is only thinly covered (areas of bedrock highs). Once any contaminants reached the water within the Jacobsville Sandstone, however, they would move laterally toward Keweenaw Bay.

Surficial spills of contaminants in the area of the industrial park would likely be confined to the upper layers of the glacial deposits. Steep slopes between the industrial park and Keweenaw Bay would tend to channel runoff over and through the shallow surficial deposits, and toward Keweenaw Bay. A more detailed study of the industrial park area, including sampling additional wells and conducting aquifer tests, would be required to make a more definitive statement about the susceptibility to contamination of the aquifer, below the industrial park and downgradient of the industrial park.

Surface Water

The Keweenaw Bay Indian Community is drained by several small creeks and drainage ditches, most of which flow to Keweenaw Bay. There are numerous small wetlands, ponds, and lakes in the Community.

Ponds and Wetlands

Within the KBIC, about 160 lakes and ponds have been identified and named (Humphrys and Green, 1962, pp. 7A-7F). Wetlands, such as the Assinins Wetlands, are significant hydrologic features of the study area. Many more unnamed, often unmapped or undelineated wetlands exist. Wetland is a general term used to define a group of wet habitats, and includes areas that are permanently wet or are intermittently water covered (Bates and Jackson, 1987, p 737). These waterbodies range in size from less than 0.1 ha to about 16 ha. None is used for public water supply.

Streams

Three streams drain most of the study area. To the west of Keweenaw Bay, the Little Carp River drains most of the area west and north of Baraga. To the south of Keweenaw Bay, tributaries of the Falls River drain the southcentral part of the study area. Silver River and its tributaries drain much of the eastern third of the study area. Small areas along the eastern shore of Keweenaw and Pequaming bays are drained by small, unnamed streams. None is used for public drinking water supply (Bedell, 1982, pp. 20-21).

Keweenaw Bay

Keweenaw Bay, the principal surface-water body within the study area, covers 45 km^2, or about one-sixth of the KBIC. The Bay reaches a depth of more than 80 m in the study area, but in most areas is about 10 to 60 m deep (Coastal Dynamics, INC., 1985, p. 6). It is the source of water for municipal supplies in Baraga and L'Anse (Bedell, 1982, pp. 20-21).

WATER QUALITY

Water samples were collected in 1991 from 11 ground-water sites and 13 surface-water sites. In 1997, eight of the ground-water sites were resampled, and 2 additional ground-water sites were sampled (figure 1). A well at the KBIC industrial park was sampled in 1997 as part of planning for possible future development. Physical characteristics of the water were measured when the samples were collected, and the samples were analyzed at the U.S. Geological Survey's National Water Quality Laboratory (NWQL) in Arvada, Colorado.

Ground Water

Ground water in the study area is generally acceptable for human consumption, with few exceptions. Results of chemical analyses are shown in table 1. The concentrations of chemical constituents in the water samples analyzed are generally less than the recommended U.S. Environmental Protection Agency (USEPA) primary maximum contaminant level (MCL) and secondary maximum contaminant levels (SMCL) for drinking water (table 2), and less than the recommended USEPA primary maximum contaminant level goal (MCLG) (United States Environmental Protection Agency, 1996). SMCLs are unenforceable federal guidelines regarding taste, odor, color, and certain other non-aesthetic effects of drinking water. USEPA recommends SMCLs to States as reasonable goals, but Federal law does not require water systems to comply with them. States may, however, adopt their own enforceable regulations governing these concerns. Exceptions are described below.

Wells 1, 3, and 9 (table 1) were sampled in 1991 but not in 1997. Well 1 is outside the current study area, in an area thought to not contribute to ground water used by the KBIC, based on ground-water flow directions shown in figure 4. Concentrations of manganese (560 µg/L) in water from well 1 exceeded the SMCL of 0.05 mg/L (50 µg/L). Manganese, under aerobic conditions or in combination with other minerals or bacteria, can cause objectionable stains, appearance, taste, and odors.

Well 3 was installed by the USGS in 1991 and removed after the field portion of the 1991 study was completed. Well 3 was a shallow (less than 3.3 m deep) well completed in lakebed sands in the Assinins Wetland. The pH of water from this well was more acidic (pH=5.8) than the USEPA SMCL (pH=6.5). An iron concentration of 1,900 µg/L, which exceeds the SMCL of 0.3 mg/L (300 µg/L), was measured in water from this well. Iron, under aerobic conditions, or in combination with other minerals or bacteria, can cause objectionable stains, appearance, taste, and odors. The zinc concentration of 2,200 µg/L of water from this well is less than the SMCL of 5 mg/L (5,000 µg/L). This zinc concentration may be due to the well construction materials and methods of installation, which consisted of driving a galvanized pipe into the ground. The acidity (low pH) of the water also could cause a reaction with the well pipe, causing zinc from the galvanizing process to enter into solution. Hardness in water from well 3 was 14 mg/L, less than the Michigan Department of Public Health minimum objectionable level for hardness of 25 mg/L. Overly soft water such as this can be corrosive to pipes, and could also cause zinc from the galvanizing process to enter into solution.

Well 9, at Zeba Michigan, is no longer used because of bacterial contamination. The well has been removed, and the borehole has been plugged. At the time well 9 was sampled in 1991, the water was within the established USEPA MCLs and SMCLs for drinking water.

Of the remaining wells, objectionable (greater than 300 µg/l) levels of iron were detected in samples from wells 5 (35,000 µg/L) and 8 (310 µg/L); objectionable (greater than 50 µg/l) levels of manganese were detected in samples from wells 5 (220 µg/L), 6 (130 µg/L), 7 (60 µg/L), and 8 (68 µg/L). Hardness was below the lower State recommended level for hardness of 25 mg/L in samples from well 5 (21 mg/L).

Of particular note is the lead level (2 µg/L) of water from well 4. USEPA MCLs do not allow for

Table 1. Chemical and physical characteristics of ground water in the Keweenaw Bay Indian Community

[Analyses by U.S. Geological Survey. --, no analysis made; <, less than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; NTU, nephelometric turbidity units; mg/L, milligrams per liter; µg/L, micrograms per liter; 420JCBV, Jacobsville Sandstone; 112LKBDS, Lakebed sands; 112SAND, Sand; 112SDGV, Sand and gravel]

Well number	Well location and owners name (Township, range, section)	Date sample collected	Time	Depth of well, total (meters)	Aquifer	Specific conduct-ance, field (µS/cm)	Water temper-ature (°C)
1	T53N R33W S24 Larry Julien	10-8-91	0930	35	420JCBV	839	8.1
2	T52N R33W S15 Garfield Hood	10-8-91	1115	46	420JCBV	338	9.0
		7-9-97	1100			279	9.0
3	T51N R33W S15 U.S. Geological Survey	8-21-91	0845	3	112LKBDS	48	13.1
4	T51N R33W S15 Assinins Catholic Church	10-8-91	1305	72	420JCBV	463	11.9
		7-8-97	1445			222	10.0
5	T51N R33W S22 The Pines	10-10-91	0840	15	112SAND	157	8.5
		7-8-97	1145			401	11.5
6	T51N R33W S27 Michael Whitty	10-9-91	1330	56	420JCBV	775	10.4
		7-8-97	1400			735	9.8
7	T50N R33W S4 Martha Koskela	10-9-91	1015	28	112SDGV	261	9.7
		7-8-97	1545			219	10.5
8	T50N R33W S3 Brewery Road Facility	10-10-91	0935	15	112SAND	407	10.7
		7-8-97	1000			329	11.0
9	T51N R32W S19 Zeba Methodist Church	10-10-91	1025	35	420JCBV	299	10.5
10	T51N R32W S8 John Seppenen	10-8-91	1540	46	112SDGV	295	9.1
		7-9-97	1300			297	8.5
11	T51N R32W S4 Robert Ramsey	10-9-91	0840	11	112SDGV	125	7.4
		7-9-97	1230			93	7.0
12	T51N R32W S19 Stan and Pauline Struce	7-10-97	1000	43	420JCBV	252	8.8
13	T51N R33W S29 Tribal Industrial Park	7-9-97	0915	131	420JCBV	180	12.0

Table 1. Chemical and physical characteristics of ground water in the Keweenaw Bay Indian Community--Continued

Well number	Turbidity (NTU)	Oxygen, dissolved (mg/L)	pH (standard units)	Silica, dissolved (mg/L as SiO2	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/l as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO4	Chloride, dissolved (mg/L as Cl)
1	1.0	3.4	8.1	6.7	64	15	64	5.7	8.3	230
2	.40	0	8.0	8.9	20	2.9	47	3.5	17	36
	.27	--	7.6	8.5	19	2.7	47	3.3	15	34
3	2.4	.6	5.8	7.8	3.7	1.2	.80	1.0	.50	.20
4	.90	1.8	7.5	6.9	11	1.3	89	2.2	20	72
	.26	--	7.1	6.2	11	1.9	50	2.5	11	14
5	23	.2	6.5	20	5.5	1.7	2.0	.70	1.4	2.4
	3.7	--	7.8	11	34	6.7	55	3.5	.40	41
6	.30	0	7.2	10	64	14	87	5.4	5.8	110
	3.7	--	7.2	8.5	73	15	86	5.4	9.3	146
7	.50	.7	8.2	13	38	9.0	4.1	1.3	1.3	5.2
	1.2	--	7.8	13	38	8.6	3.8	1.3	1.5	3.5
8	1.0	.1	8.0	18	49	15	16	2.4	<.1	28
	4.7	--	7.8	17	48	15	15	2.4	<.1	26
9	85	.5	7.1	11	39	5.2	18	2.3	5.3	13
10	.40	1.3	7.9	21	37	16	3.9	4.4	3.2	1.8
	.2	--	7.9	19	35	15	3.6	4.3	2.5	.28
11	1.4	4.4	7.1	12	16	4.1	1.6	1.2	9.6	2.1
	2.2	--	6.5	12	14	3.5	1.4	1.2	5.9	1.0
12	.14	--	7.8	9.7	18	2.2	52	1.2	4.1	4.0
13	.26	--	7.6	10	27	7.4	5.9	1.5	6.5	1.2

Well number	Fluoride, dissolved (mg/L as F)	Nitrogen, ammonia, total (mg/L as N	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, $NO_2 + NO_3$, total (mg/L as N)	Nitrogen, $NO_2 + NO_3$, dissolved (mg/L as N)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrate, total (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Nitrogen, organic + ammonia, total (mg/L as N)
1	0.30	0.010	<0.010	<0.05	<0.05	<0.01	--	--	<0.20
2	.30	<.010	<.010	<.05	<.05	<.01	--	--	<.20
	.37	--	<.015	--	<.05	<.01	--	--	<.20
3	<.10	.190	.160	<.05	<.05	<.01	--	0.31	.500
4	.60	<.010	<.010	<.05	<.05	<.01	--	--	<.20
	.27	--	<.015	--	.084	<.01	--	--	<.20
5	.20	.310	.340	<.05	<.05	.01	--	.39	.700
	.30	--	.340	--	<.05	<.01	--	--	.495
6	.20	.021	.010	<.05	<.05	<.01	--	--	<.20
	.21	--	<.015	--	<.05	<.01	--	--	<.20
7	.10	2.80	2.80	.190	.210	.05	0.14	.30	3.10
	<.1	--	<.015	--	<.05	<.01	--	--	<.20
8	.20	.090	.080	<.05	<.05	<.01	--	--	<.20
	.23	--	.029	--	<.05	<.01	--	--	<.20
9	<.1	.050	.021	.360	.350	.03	.33	--	<.20
10	.20	.021	<.010	.100	.120	<.01	--	--	<.20
	.22	--	<.015	--	.086	<.01	--	--	<.20
11	.10	<.010	<.010	.171	.171	<.01	--	--	<.20
	<.1	--	<.015	--	.069	<.01	--	--	<.20
12	.10	--	<.015	--	.066	<.01	--	--	<.20
13	<.1	--	<.015	--	<.05	<.01	--	--	<.20

Table 1. Chemical and physical characteristics of ground water in the Keweenaw Bay Indian Community--Continued

Well number	Phosphorus, ortho, total (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, dissolved (mg/L as P)	Phenols, total (µg/L)	Alkalinity, field (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Bicarbonate, dissolved (mg/L as HCO_3)	Solids, sum of constituents, dissolved (mg/L)	Solids, residue at 180 °C, dissolved (mg/L)
1	<0.010	0.021	<0.010	<1	60	220	160	73	433	467
2	<.010	.021	<.010	<1	106	62	--	129	201	197
	<.010	<.010	<.010	--	115	60	--	--	194	205
3	<.010	.080	.010	2	20	14	--	24	31	43
4	<.010	.030	.010	1	106	33	--	129	271	271
	.030	.026	.010	--	125	37	--	--	170	171
5	.290	.310	.310	1	66	21	--	81	83	138
	<.010	<.010	<.010	--	235	120	--	--	271	292
6	<.010	.021	.010	1	136	220	--	166	453	436
	<.010	<.010	<.010	--	315	250	--	--	498	526
7	<.010	<.010	<.010	1	132	130	--	161	161	147
	<.010	<.010	<.010	4	170	130	--	--	153	156
8	<.010	.010	.041	1	184	180	--	224	--	232
	<.010	<.010	<.010	--	235	180	--	--	--	245
9	.050	.060	<.010	1	122	120	--	131	178	172
10	<.010	.010	<.010	1	160	160	--	195	189	168
	.010	<.010	<.010	--	185	150	--	--	180	181
11	<.010	<.010	<.010	1	58	57	71	71	77	80
	<.010	<.010	<.010	--	60	50	--	--	70	79
12	<.010	<.010	<.010	3	190	56	--	--	194	207
13	.012	<.010	.013		135	100	--	--	126	129

Well number	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)
1	20	<1	980	<0.5	<1.0	<1	<3	<1	83	<1	26
2	20	3	100	1	<1.0	<1	<3	2	10	<1	20
	8.0	--	94	--	--	--	<3	--	9.9	--	18
3	110	<1	15	<.5	2.0	<1	5	<1	1,900	<1	<4.0
4	20	<1	77	<.5	<1.0	3	<3	75	22	2	48
	12	--	76	--	--	--	<3	--	13	--	29
5	100	<1	60	<.5	<3.0	<5	<3	7	35,000	<1	<4.0
	<5.0	--	2,205	--	--	--	4.8	--	453	--	40
6	<10	<1	650	<.5	<1.0	<1	<3	2	25	<1	75
	<5.0	--	759	--	--	--	<3	--	152	--	67
7	10	<1	130	<.5	<1.0	<1	<3	5	100	<1	6.0
	<5.0	--	138	--	--	--	<3	--	86	--	4.9
8	10	2	210	<.5	<1.0	<1	<3	<1	310	<1	9.0
	<5.0	--	222	--	--	--	<3	--	107	--	7.0
9	20	<1	530	<.5	<1.0	1	<3	2	100	<1	23
10	20	2	100	<.5	<1.0	<1	<3	1	48	<1	15
	<5.0	--	103	--	--	--	<3	--	22	--	11
11	20	<1	60	<.5	<1.0	<1	<3	5	95	<1	<4.0
	11	--	60	--	--	--	9.9	--	675	--	<4.0
12	<5.0	--	449	--	--	--	<3	--	4.7	--	36
13	11	--	77	--	--	--	<3	--	10	--	5.0

Table 1. Chemical and physical characteristics of ground water in the Keweenaw Bay Indian Community--Continued

Well number	Manga-nese, dis-solved (µg/L as Mn)	Mer-cury, dis-solved (µg/L as Hg)	Molyb-denum, dis-solved (µg/L as Mo)	Nickel, dis-solved (µg/L as Ni)	Sele-nium, dis-solved (µg/L as Se)	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Tritium,[1] total (pCi/L)
1	560	<0.1	<10	<1	<1	<1.0	400	<6	18	--
2	7.0	<.1	<10	1	<1	<1.0	430	270	10	--
	5.7	--	<10	<1	<1	<1.0	435	200	--	10.6±3.2
3	45	<.1	<10	1	<1	<1.0	17	<6	2200	--
4	5.0	<.1	20	1	<1	<1.0	240	9	180	--
	4.2	--	<10	<1	<1	<1.0	221	36	--	23.4±3.8
5	220	<.1	<10	2	<1	<1.0	30	40	54	--
	104	--	<10	1.5	<1	<1.0	699	<6	--	21.8±3.2
6	130	<.1	<10	<1	<1	<1.0	1200	<6	30	--
	132	--	<10	<1	<1	<1.0	1316	<6	--	29.1±3.8
7	60	<.1	<10	<1	<1	<1.0	94	<6	23	--
	61	--	<10	<1	<1	<1.0	94	<6	--	<5.7±3.2
8	68	<.1	<10	<1	<1	<1.0	270	<6	9.0	--
	61	--	<10	<1	<1	<1.0	273	<6	--	<5.7±3.2
9	24	<.1	<10	<1	<1	<1.0	640	<6	560	--
10	2.0	<.1	<10	<1	<1	<1.0	190	9	210	--
	<1.0	--	<10	<1	<1	<1.0	199	8	--	<5.7±3.2
11	6.0	.8	<10	1	<1	<1.0	30	<6	20	--
	38	--	<10	<1	<1	<1.0	28	<6	--	49.6±4.5
12	3.2	--	<10	<1	<1	<1.0	315	<6	--	19.2±3.8
13	2.0	--	<10	<1	<1	<1.0	107	<6	--	67.2±5.8

1. For concentrations above the method reporting limit (5.7 pCi/L), the number given is the tritium concentration and the 2-sigma uncertainty reported by the lab.

Table 2. Drinking-water regulations of the U.S. Environmental Protection Agency

[TT, treatment technique; unless otherwise specified, units of measurement are in milligrams per liter (mg/L); MFL, million fibers per liter; pCi/L, picocuries per liter; --, no level set or proposed. Data retrieved on 11/19/96 from the World Wide Web at http://www.epa.gov/OST/Tools/dwstds.html, U.S. Environmental Protection Agency, 1996]

Contaminant	Maximum contaminant level goal	Maximum contaminant level	Secondary maximum contaminant level
National primary drinking water standards			
Acrylamide	zero	TT[1]	--
Alachlor (Lasso)	zero	0.002	--
Aldicarb[2]	0.001	.003	--
Aldicarb Sulfone[2]	.001	.002	--
Aldicarb Sulfoxide[2]	.001	.004	--
Antimony	.006	.006	--
Asbestos	7 MFL	7 MFL	--
Atrazine (Atranex, Crisazina)	.003	.003	--
Arsenic	none[3]	.05	--
Barium	2	2	--
Benzene	zero	.005	--
Benzo[a]Pyrene (PAH)	zero	.0002	--
Beryllium	.004	.004	--
Beta Particle & Photon Emitters	zero	4 mrem/yr	--
Cadmium	.005	.005	--
Carbofuran (Furadan 4F)	.04	.04	--
Carbon Tetrachloride	zero	.005	--
Chlordane	zero	.002	--
Chromium	.1	.1	--
Copper	1.3	TT[4]	1.0
Cyanide	.2	.2	--
2,4-D (Formula 40, Weeder 64)	.07	.07	--
Dalapon	.2	.2	--
Di(2-ethylhexyl)adipate	.4	.4	--
Di(2-ethylhexyl)phthalate	zero	.006	--
Dibromochloropropane (DBCP)	zero	.0002	--
o-Dichlorobenzene	.6	.6	--
p-Dichlorobenzene	.075	.075	--
1,2-Dichloroethane	zero	.005	--
1,1-Dichloroethylene	.007	.007	--
cis-1,2-Dichloroethylene	.07	.07	--
trans-1,2-Dichloroethylene	.1	.1	--
Dichloromethane	zero	.005	--
1,2-Dichloropropane	zero	.005	--
Dinoseb	.007	.007	--
Diquat	.02	.02	--
Endothall	.1	.1	--
Endrin	.002	.002	--
Epichlorohydrin	zero	TT[1]	--
Ethylbenzene	.7	.7	--

Table 2. Drinking-water regulations of the U.S. Environmental Protection Agency --Continued

Contaminant	Maximum contaminant level goal	Maximum contaminant level	Secondary maximum contaminant level
Ethylene dibromide	zero	.00005	--
Flouride[5]	4.0	4.0	2.0
Giardia Lamblia	zero	TT[6]	--
Glyphosate	.7	.7	--
Gross Alpha Particle Activity	zero	15 pCi/L	--
Heptachlor (H-34, Heptox)	zero	zero	--
Heptachlor Epoxide	zero	.0002	--
Heterotrophic Plate Count	zero	TT[5]	--
Hexachlorobenzene	zero	.001	--
Hexachlorocyclopentadiene	.05	.05	--
Lead	zero	TT[4]	--
Legionella	zero	TT[5]	--
Lindane	.0002	.0002	--
Methoxychlor (DMDT, Marlate)	.04	.04	--
Monochlorobenzene	.1	.1	--
Mercury	.002	.002	--
Nickel	.1[7]	.1[6]	--
Nitrate (as nitrogen)	10	10	--
Nitrite (as nitrogen)	1	1	--
Total Nitrate/Nitrite	10	10	--
Oxamyl (Vydate)	.2	.2	--
Pentachlorophenol	zero	.001	--
Picloram	.5	.5	--
Polychlorinated Bipenyls (PCBs)	zero	.0005	--
Radium 226 & Radium 228 Comb.	zero	5 pCi/L	--
Selenium	.05	.05	--
Simazine	.004	.004	--
Styrene	.1	.1	--
Sulfate	deferred[8]	deferred[8]	250
2,3,7,8-TCDD (Dioxin)	zero	.00000003	--
Tetrachloroethylene	zero	.005	--
Thallium	.0005	.002	--
Toluene	1	1	--
Total Coliforms	zero	none	--
Total Trihalomethanes	----	.1	--
Toxaphene	zero	.003	--
2,4,5-TP (Silvex)	.05	.05	--
1,2,4-Trichlorobenzene	.07	.07	--
1,1,1-Trichloroethane	.2	.2	--
1,1,2-Trichloroethane	.003	.005	--
Trichloroethylene	zero	.005	--
Turbidity	zero	TT[5]	--
Vinyl Chloride	zero	.002	--
Viruses	zero	TT[5]	--
Xylenes	10	10	--

Table 2. Drinking-water regulations of the U.S. Environmental Protection Agency- -Continued

Contaminant	Maximum contaminant level goal	Maximum contaminant level	Secondary maximum contaminant level
	National secondary drinking water standards[9]		
Aluminum	--	--	.05 to .20
Chloride	--	--	250
Color	--	--	15 color units
Corrosivity	--	--	noncorrosive
Foaming agents	--	--	.5
Iron	--	--	.3
Manganese	--	--	.05
Odor	--	--	3 threshold odor numbers
pH	--	--	6.5-8.5
Silver	--	--	.1
Total Dissolved Solids(TDS)	--	--	500
Zinc	--	--	5
Conductivity[10]	--	--	--
Hardness[11]	--	--	--
Sodium[12]	--	--	--

1. Each Public Water System must certify annually in writing to the State (using third-party or manufacturer's certification) that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified as follows: (1) Acrylamide = 0.05% dosed at 1 ppm (or equivalent) and (2) epichlorohydrin = 0.01% dosed at 20 ppm (or equivalent).
2. These levels are not in effect. EPA plans to repropose levels in the future.
3. The Maximum Contaminant Level Goal (MCLG) for this contaminant was withdrawn and is currently under review.
4. The lead and copper rule is a treatment technique that requires water systems to take tap water samples from homes with lead pipes or copper pipes with lead solder and/or with lead service lines. If more than 10 percent of these samples exceed an action level of 1.3 mg/L for copper or 0.015 mg/L for lead, the system is triggered into additional treatment.
5. Under review.
6. These contaminants are regulated under the Surface Water Treatment Rule (40 CFR 141.70-141.75).
7. The Maximum Contaminant Level Goal (MCLG) and Maximum Contaminant Level (MCL) for nickel have been withdrawn.
8. The proposed Maximum Contaminant Level Goal (MCLG) and Maximum Contaminant Level (MCL) for Sulfate is 500 mg/L.
9. Secondary Drinking Water Standards are unenforceable federal guidelines regarding taste, odor, color, and certain other non-aesthetic effects of drinking water. EPA recommends them to States as reasonable goals, but federal law does not require water systems to comply with them. States may, however, adopt their own enforceable regulations governing these concerns.
10. Michigan Department of Public Health has set the objectionable level at 850 μS/cm or greater.
11. Michigan Department of Public Health has set the objectionable level at less than 25 or greater than 250 mg/L.
12. Michigan Department of Public Health has set the objectionable level at 250 mg/L or greater.

the presence of lead, and recommend treatment of water containing even small amounts of lead. Because no blank samples (water of known quality that help identify possible sources of contamination) were prepared at the time this sample was taken, it is not possible to say with certainty that the lead originated in the aquifer. It is possible that the measured lead concentration is an artifact of the sampling equipment, or that it resulted from leaching of lead at solder joints in plumbing in the household from which the sample was taken.

Turbidity was above the MCL and MCLG (both of which require treatment to 0.0 NTU) in all samples (0.30-85 NTU); however, this is a level set for public water supplies on the assumption that all suppliers of public water have the ability to filter and treat the water in such as a way as to decrease turbidity to zero. This is a standard set for aesthetic reasons, and the turbidity levels reported for water from all wells is below any noticeable or objectionable level.

Ground-Water Types

Ground-water samples collected in this study can be recognized on the basis of their major-ion composition, as illustrated in figure 5. Water from the glacial aquifers is typically a calcium-magnesium-bicarbonate type, whereas water from the Jacobsville Sandstone aquifer is more variable in composition. This variability is likely a consequence of areal and vertical differences in the hydraulic characteristics and lithologic composition of the Jacobsville Sandstone. Most of the wells sampled are open to long intervals of rock; therefore, water samples from a single well likely represent mixtures of water from several depths within the aquifer.

In general, sodium and calcium are the principal cations in ground water in the western part of the study area, with decreasing sodium and increasing calcium and magnesium concentrations toward the east. Chloride is the principal anion in ground water in the western part of the study area, with decreasing chloride and increasing bicarbonate concentrations toward the east.

Surface Water

In 1991, the Assinins Wetland was evaluated as a potential site for fish farming. Measurements of streamflow at the wetland's inlets and outlet (fig. 6) were made during high and low-flow conditions. A gage was installed to measure seasonal fluctuations in water stage and water temperature in the wetland. Three 5.1-cm diameter wells were installed in the glacial deposits to determine aquifer lithology and water quality. A continuous recorder was installed on the center well (KEW2R) to measure water-table fluctuations. Streamflow and water quality were measured at 11 streams.

Water samples were collected at two locations in the wetland, at one down-gradient well, and at the wetland's outlet (fig. 6), to determine the quality of water discharging to and from the wetland. The samples were analyzed for common dissolved substances, trace metals, nutrients, bacteria, phenols, pesticides, and volatile organics. Temperature, pH, specific conductance, dissolved oxygen, and alkalinity of water samples were measured in the field. Results of analyses of water samples from the Assinins Wetland are in table 3; results of analyses of water samples from streams are in table 4.

Sediment samples were collected at two locations in the wetland (fig. 6) and at three stream sites (fig. 6). The samples were analyzed for trace metals. Results of the analyses of sediment samples from the Assinins Wetland are in table 3; results of the analyses of sediment samples from the streams are in table 4. These data were collected in 1991 to provide a basis for assessing the potential use of the Assinins Wetland as fish rearing ponds, and the general quality of Keweenaw Bay with respect to fisheries management issues. The data collection for this work was not completed; hence, no assessment is made of the quality of water in Keweenaw Bay, nor is the quality of the water sampled related to water quality standards for fishery management.

The chemical characteristics of water from all 3 sources at Assinins Wetland (well, wetland, stream) sampled are similar, likely reflecting similar sources. Streams were sampled near their mouths, either upstream of their confluence with other streams, or upstream of where they enter Keweenaw Bay. The wetland was sampled at 2 locations, one near the point where water is believed to exit the wetland, and one near the center of a chain of apparently

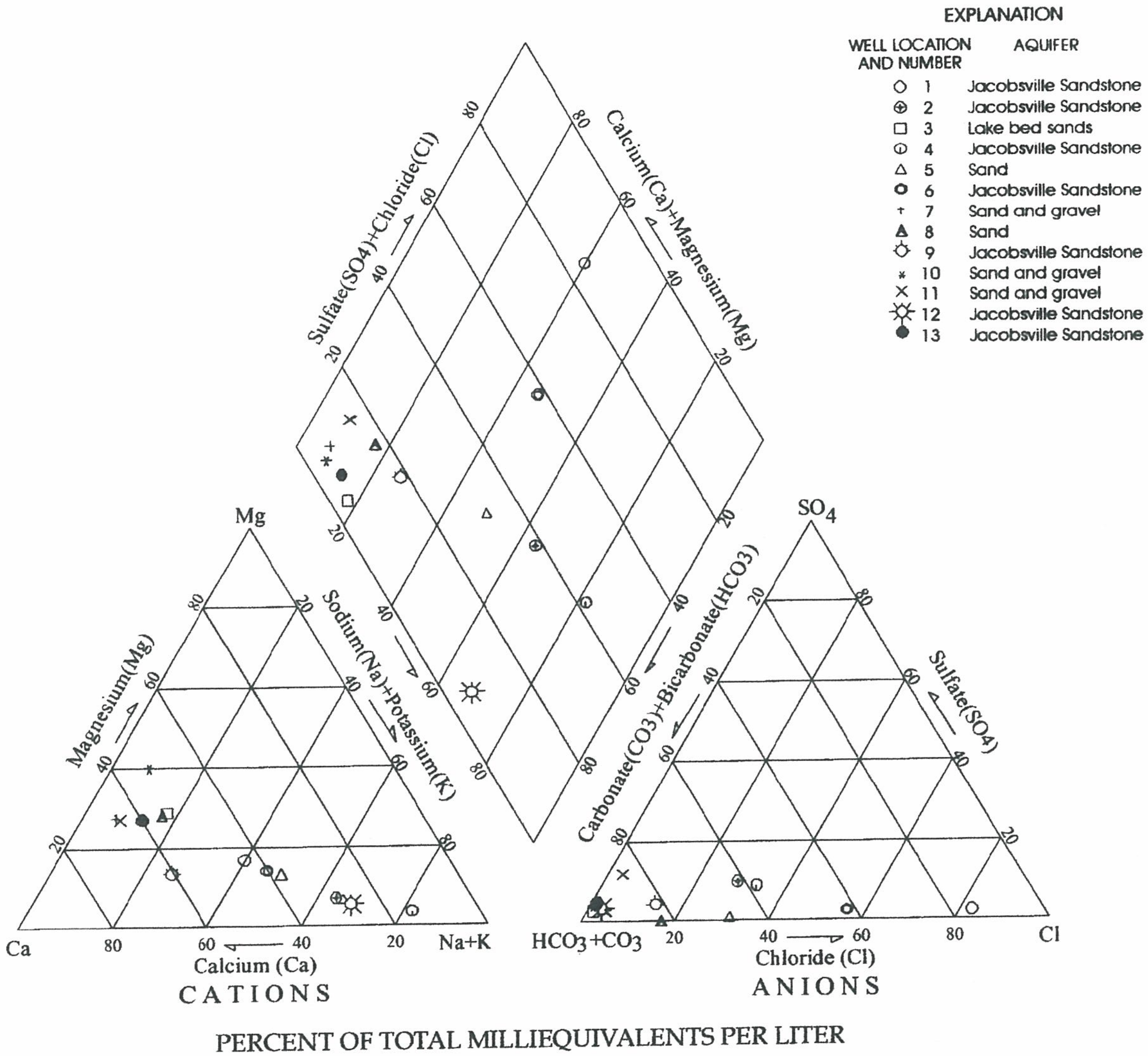

Figure 5. Trilinear diagram of ground-water chemistry, Keweenaw Bay Indian Community (1991 and 1997 data).

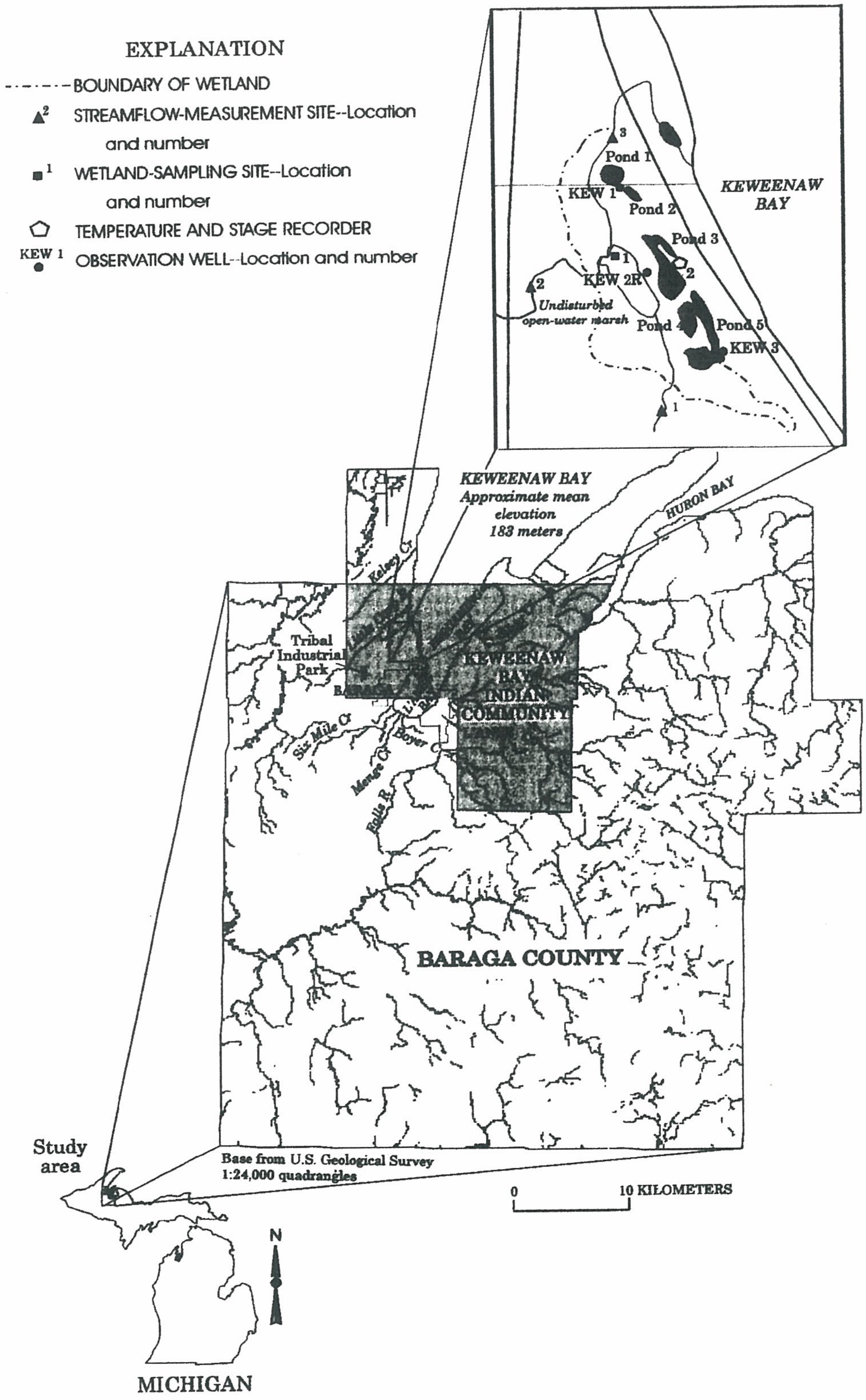

Figure 6. Location of wetlands and surface-water sites, 1991.

Table 3. Chemical and physical characteristics of water of the Assinins Wetland in the Keweenaw Bay Indian Community

[Analyses by U.S. Geological Survey. --, no analysis made; <, less than; µs/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; µg/L, micrograms per liter; mg/L, milligrams per liter; NTU, nephelometric turbidity units]

Site number	Station number and name	Date sample collected	Time	Total depth of water column (meters)	Specific conductance, field (µS/cm)	Water temperature (°C)	Turbidity (NTU)	Color (platinum-cobalt units)	Oxygen, dissolved (mg/L)
1	464916088290101 — Assinins Wetland (marsh)	8-21-91	1040	3	108	15.5	4.0	70	6.0
2	464912088285401 — Assinins Wetland (pond 3)	8-21-91	1330	1	81	22.7	4.1	50	7.6

Site number	pH (standard units)	Silica, dissolved (mg/L as SiO_2)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)
1	7.4	9.4	17	4.1	1.6	1.0	1.1	0.30	<0.10	0.18	.018
2	7.6	4.6	11	3.0	1.3	0.60	0.60	.30	<.10	.36	.371

Site number	Nitrogen, $NO_2 + NO_3$, total (mg/L as N)	Nitrogen, $NO_2 + NO_3$, dissolved (mg/L as N)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrate, total (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Nitrogen, organic + ammonia, total (mg/L as N)	Phosphorus, ortho, total (mg/L as P)	Phosphorus, total (mg/L as P)	Carbon, organic, dissolved (mg/L as C)	Hydrogen sulfide, total (mg/L as H2S)
1	<0.05	<0.05	0.01	--	0.92	1.1	<0.01	0.041	11	<0.5
2	<.05	<.05	<.01	--	.64	1.0	<.01	.041	14	<.5

Site number	Phenols, total (µg/L)	Alkalinity, field (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Bicarbonate, dissolved (mg/L as HCO_3)	Solids, sum of constituents, dissolved (mg/L)	Solids, residue at 180 °C, dissolved (mg/L)	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved, (µg/L as As)	Barium, dissolved, (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)
1	2	58	59	71	71	96	20	<1	34	<0.5	2.0
2	1	37	40	46	46	79	20	<1	35	.8	<1.0

Site number	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Iron, Dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)
1	<1	<3	4	2,700	<1	<4	310	<0.1	<10	<1	<1
2	<1	<3	2	400	<1	<4	8	.4	<10	<1	<1

Table 3. Chemical and physical characteristics of water of the Assinins Wetland in the Keweenaw Bay Indian Community--Continued

Site number	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Coliform, fecal, 0.7 mM-MF (cols/100 ml)	Strepto-cocci, fecal, KF Agar (cols/100 ml)	Arsenic, bottom mate-rial (µg/g as As)	Beryl-lium, bottom mate-rial (µg/g as Be)	Cad-mium, bottom mate-rial (µg/g as Cd)	Chro-mium, bot-tom mate-rial (µg/g as Cr	Cop-per, bot-tom mate-rial (µg/g as Cu)
1	<1.0	34	<6	26	--	--	--	--	--	--	--
2	<1.0	27	<6	6	20	33	4	<1	<2	20	50

Site number	Lead, bottom mate-rial (µg/g as Pb)	Nickel, bottom mate-rial (µg/g as Ni)	Zinc, bottom mate-rial (µg/g as Zn)	Sele-nium, bottom material (µg/g as Se)	Mer-cury, bot-tom material (µg/g as Hg)
1	--	--	--	--	--
2	60	20	120	<1	0.06

Table 4. Chemical and physical characteristics of water in streams in the Keweenaw Bay Indian Community
[Analyses by U.S. Geological Survey. --, no analysis made; <, less than; m^3/s, cubic meters per second; µs/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; µg/L, micrograms per liter; mg/L, milligrams per liter; NTU, nephelometric turbidity units]

Site number	Station number and name	Date sample collected	Time	Streamflow, instantaneous (m^3/s)	Specific conductance, field (µS/cm)	Water temperature (°C)	Turbidity (NTU)
1	04043060 — Kelsey Creek near Keweenaw Bay	10-31-91	1300	1.23	79	4.0	2.5
2	04043065 — Little Carp River near Keweenaw Bay	10-31-91	1430	1.90	111	5.0	2.0
3	04043068 — Assinins Wetland Outlet at Assinins	8-21-91	1130	.05	199	19.0	2.6
		10-31-91	0945	1.87	132	5.0	1.5
4	04043069 — Tangen Creek at Baraga	10-30-91	1645	.09	157	5.5	4.6
5	04043070 — Hazel Creek near Baraga	10-30-91	1500	2.28	284	6.0	2.0
6	04043080 — Six Mile Creek near Baraga	10-29-91	1220	18.1	177	7.0	1.6
7	04043085 — Menge Creek near Baraga	10-29-91	1415	9.42	215	7.5	1.7
8	04043090 — Boyers Creek near Baraga	10-29-91	1520	.89	223	8.0	4.7
9	04043100 — Falls River at L'Anse	10-30-91	1220	44.4	145	5.0	1.3
10	04043105 — Linden Creek at L'Anse	10-30-91	1000	4.20	267	7.0	4.4
11	04043120 — Little Silver Creek near L'Anse	10-30-91	0820	.471	219	3.0	1.0

Site number	Color (platinum-cobalt units)	Oxygen, dissolved (mg/L)	pH (standard units)	Silica, dissolved (mg/L as SiO2)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO4)	Chloride, dissolved (mg/L as Cl)
1	51	12.5	7.4	5.0	7.9	1.6	2.4	1.7	2.6	2.3
2	54	12.0	7.6	6.9	13	3.8	2.9	1.5	3.2	4.3
3	47	3.5	7.5	7.2	29	6.8	2.2	0.70	1.3	0.4
	42	9.6	7.4	6.3	17	4.9	1.9	.80	2.0	1.1

Table 4. Chemical and physical characteristics of water in streams in the Keweenaw Bay Indian Community--Continued

Site number	Color (platinum-cobalt units)	Oxygen, dissolved (mg/L)	pH (standard units)	Silica, dissolved (mg/L as SiO2)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO4)	Chloride, dissolved (mg/L as Cl)
4	130	10.6	7.4	7.0	17	4.4	6.2	2.3	9.9	13
5	21	8.2	7.8	12	36	8.8	9.5	2.0	3.7	12
6	11	11.1	8.1	10	25	6.1	2.4	.90	4.9	1.5
7	12	10.6	8.0	11	32	7.4	2.0	1.1	7.0	1.7
8	51	11.2	8.0	9.1	31	8.4	2.9	2.4	15	2.8
9	52	12.8	7.8	7.9	20	4.3	2.6	.90	6.0	4.4
10	25	11.1	7.6	10	31	6.9	11	2.5	14	18
11	21	12.0	7.8	12	33	6.8	4.0	1.3	7.1	4.5

Site number	Fluoride, dissolved (mg/L as F)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, nitrite, total (mg/L as N)	Nitrogen, nitrate, total (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Nitrogen, organic + ammonia, total (mg/L as N)
1	<0.10	0.021	0.021	<0.05	<0.05	<0.01	--	0.38	0.40
2	.20	.041	.030	<.05	<.05	<.01	--	.46	.50
3	<.10 .20	.021 .041	.01 .03	<.05 <.05	<.05 <.05	<.01 <.01	-- --	1.4 .46	1.4 .50
4	.20	.07	.07	<.05	<.05	<.01	--	.63	.70
5	.10	.24	.25	.371	.43	.021	0.35	.16	.40
6	.20	.03	.03	<.05	.059	<.01	--	--	<.20
7	.20	.03	<.01	<.05	.064	<.01	--	--	<.20
8	.20	.03	<.01	<.05	<.05	<.01	--	.47	.50
9	.20	.021	.01	<.05	<.05	<.01	--	.28	.30
10	.20	.51	.50	1.70	1.70	.11	1.59	.49	1.0
11	.20	.03	<.01	.50	.50	<.01	--	--	<.20

Table 4. Chemical and physical characteristics of water in streams in the Keweenaw Bay Indian Community--Continued

Site number	Phosphorus, ortho, total (mg/L as P)	Phosphorus, total (mg/L as P)	Carbon, organic, dissolved (mg/L as C)	Sediment, suspended (mg/L)	Sediment, suspended, % finer than .062 mm sieve	Phenols, total (µg/L)	Alkalinity, field (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Bicarbonate, dissolved (mg/L as HCO_3)	Solids, sum of constituents, dissolved (mg/L)	Solids, residue at 180 °C, dissolved (mg/L)
1	0.021	0.021	14	4	75	<1	14	26	17	39	49
2	.021	.021	0.021	7	--	<1	42	48	51	64	72
3	<.01	.03	8.9	--	--	1	102	100	124	109	128
	<.01	<.01	11	4	84	1	59	63	72	79	82
4	<.01	<.01	22	3	78	<1	40	61	49	90	115
5	.01	.041	12	4	75	<1	122	130	149	161	163
6	<.01	<.01	4.9	6	48	1	90	88	110	105	104
7	<.01	.021	8.4	11	55	2	91	110	111	127	123
8	.01	.021	14	6	82	1	104	110	127	136	145
9	<.01	<.01	8.6	2	90	<1	64	68	78	86	95
10	.03	.06	9.3	4	94	1	90	110	110	151	163
11	<.01	<.01	6.3	2	40	3	100	110	122	133	135

Site number	Aluminum, dissolved (µg/L as Al)	Arsenic, dissolved (µg/L as Al)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)
1	40	--	43	--	--	--	<3	--	330	--	<4	52
2	40	<1	46	<0.5	<1.0	1	<3	2	500	2	<4	19
3	60	<1	56	.8	<1.0	<1	<3	1	1,300	<1	<4	210
	30	<1	36	<.5	<1.0	<1	<3	<1	210	<1	<4	16
4	160	<1	59	<.5	<1.0	<1	<3	8	930	<1	<4	54
5	20	1	100	<.5	<1.0	<1	<3	9	130	<1	<4	90
6	30	2	60	<.5	<1.0	1	<3	<1	72	<1	<4	9
7	30	1	48	<.5	<1.0	<1	<3	<1	53	<1	<4	6
8	40	<1	47	<.5	<1.0	<1	<3	1	160	<1	<4	12
9	50	<1	27	<.5	<1.0	<1	<3	1	140	<1	<4	8
10	30	<1	61	<.5	<1.0	<1	<3	2	170	<1	<4	38
11	10	<1	130	<.5	<1.0	<1	<3	22	34	<1	<4	25

Table 4. Chemical and physical characteristics of water in streams in the Keweenaw Bay Indian Community--Continued

Site number	Mercury, dis-solved (μg/L as Hg)	Molyb-denum, dis-solved (μg/L as Mo)	Nickel, dis-solved (μg/L as Ni)	Sele-nium, dis-solved (μg/L as Se)	Silver, dis-solved (μg/L as Ag)	Stron-tium, dis-solved (μg/L as Sr)	Vana-dium, dis-solved (μg/L as V)	Zinc, dis-solved (μg/L as Zn)	Coliform, fecal, 0.7 μM-MF (cols/100 ml)	Strep-tococci, fecal, KF Agar (cols/100 ml)
1	--	<10	<1	<1	<1.0	40	<6	--	56	7
2	<0.1	<10	<1	<1	<1.0	51	<6	16	1	7
3	<.1	<10	<1	<1	<1.0	53	<6	15	180	42
	<.1	<10	<1	<1	<1.0	33	<6	88	4	31
4	<.1	<10	<1	<1	<1.0	70	<6	9	43	52
5	<.1	<10	<1	<1	<1.0	63	<6	3	32	29
6	<.1	<10	<1	<1	<1.0	45	<6	<3	10	36
7	<.1	<10	2	<1	<1.0	40	<6	6	7	72
8	<.1	<10	<1	<1	<1.0	59	<6	<3	4	43
9	<.1	<10	<1	<1	<1.0	31	<6	10	10	80
10	<.1	<10	<1	<1	<1.0	56	<6	21	7	37
11	<.1	<10	1	<1	<1.0	90	<6	<3	3	11

Site number	Arsenic, bottom material (μg/g as As)	Beryl-lium, bottom material (μg/g as Be)	Cadmium, bottom material (μg/g as Cd)	Chro-mium, bottom material (μg/g as Cr)	Copper, bottom material (μg/g as Cu)	Lead, bottom material (μg/g as Pb)	Mercury, bottom material (μg/g as Hg)	Nickel, bottom material (μg/g as Ni)	Sele-nium, bottom material (μg/g as Se)	Zinc, bottom material (μg/g as Zn)
5	7	<1	<1	2	10	<10	<10	<10	<1	0.01
9	3	<1	<1	2	3	<10	<10	<10	<1	.01
10	<1	<1	<1	2	3	<10	<10	<10	<1	<.01

unconnected, undrained ponds. One well, near what is believed to be the down-gradient end of the wetland, also was sampled.

Water samples are grouped on the basis of their major-ion composition, as shown in figure 7. Water from the wetland well is a calcium-magnesium-bicarbonate type, and surface water in the wetland is a calcium-bicarbonate type. Stream water quality is slightly more variable, but the dominant anion remains bicarbonate. Calcium is the dominant cation of stream water; however, significant concentrations of magnesium and sodium are also present in some samples.

Comparison of the wetland-area samples to the ground-water samples collected in 1991 and 1997 (table 1) indicates that they are chemically similar to the samples from the alluvial and glacial sand and sand-and-gravel aquifers. It is likely that baseflow to these streams is dominantly ground-water discharge from the glacial aquifers, and that its composition changes only slightly or not at all during flow through the wetland. Although interactions between surface water and ground water may be important in determining some aspects of the status of ground-water supplies for the KBIC, no additional samples were collected nor measurements made in 1997.

SUMMARY AND CONCLUSIONS

The Keweenaw Bay Indian Community, in Michigan's western Upper Peninsula, is dependent upon its aquifers for drinking water and water for other uses. Throughout the community, ground water is readily available, although sometimes at depths greater than 60 m. The community of Baraga lies wholly in the study area; the north part of the village of L'Anse is in the study area. Both communities draw water from Keweenaw Bay for their municipal supplies.

The development of an industrial park on the west side of the KBIC has caused concerns for the safety of the aquifers, as the park is sited near a ground-water divide. Should contaminants be released in the park, there is a potential for contamination of down-gradient water supplies.

Most of the study area is moderately to steeply sloping, with thin alluvial and glacial deposits of unconsolidated materials overlying bedrock. The thickness of unconsolidated deposits ranges from being locally absent to having a thickness of more than 30 m. Glacial deposits are used for water supplies in 2 parts of the study area.

The principal aquifer in the study area is the Jacobsville Sandstone. Water is produced primarily from fractures and bedding planes. Analyses of pump tests in 21 wells completed in the aquifer indicated hydraulic conductivities of 10^{-4} to 10^{1} m/d and storage coefficients of 10^{-5}. Storage coefficients of this magnitude are indicative of confined conditions.

Water levels in the Jacobsville Sandstone generally indicate confined conditions, except for an area in 2 sections immediately north of Baraga, and east and down gradient from the industrial park. Locally, the aquifer is unconfined in areas of bedrock highs in the west and east parts of the study area, and in areas of outcrop along the Keweenaw Bay shoreline and valleys of small streams that drain the area. Along the Keweenaw Bay shoreline, where overlain by alluvium and glacial deposits, the aquifer is generally confined.

Water samples were collected in 1991 and 1997 to assess the current water quality in the study area, and provide information on natural and anthropogenic processes that affect water quality. Samples were collected from 11 wells in 1991 and 10 wells in 1997. Eight of the wells were sampled in both years. Three of the wells used in 1991 were either outside of the current study area or were no longer in use in 1997. The industrial park well was sampled only in 1997. Also in 1997, a well that had been removed after 1991 was replaced by a well of similar construction, and near to the discontinued well.

In general, ground-water quality is suitable for domestic, commercial, and industrial uses. Concentrations of some constituents fail to meet USEPA MCL, SMCL, or MCLG's and Michigan standards for domestic use in only a few wells. The most common ground-water quality problem in the study area is large concentrations of dissolved iron (310 - 35,000 µg/L), followed by large concentrations of dissolved manganese (60 - 560 µg/L). Water from one well had detectable levels of lead in 1991.

Water from the surficial aquifers is predominantly a calcium-magnesium-bicarbonate type.

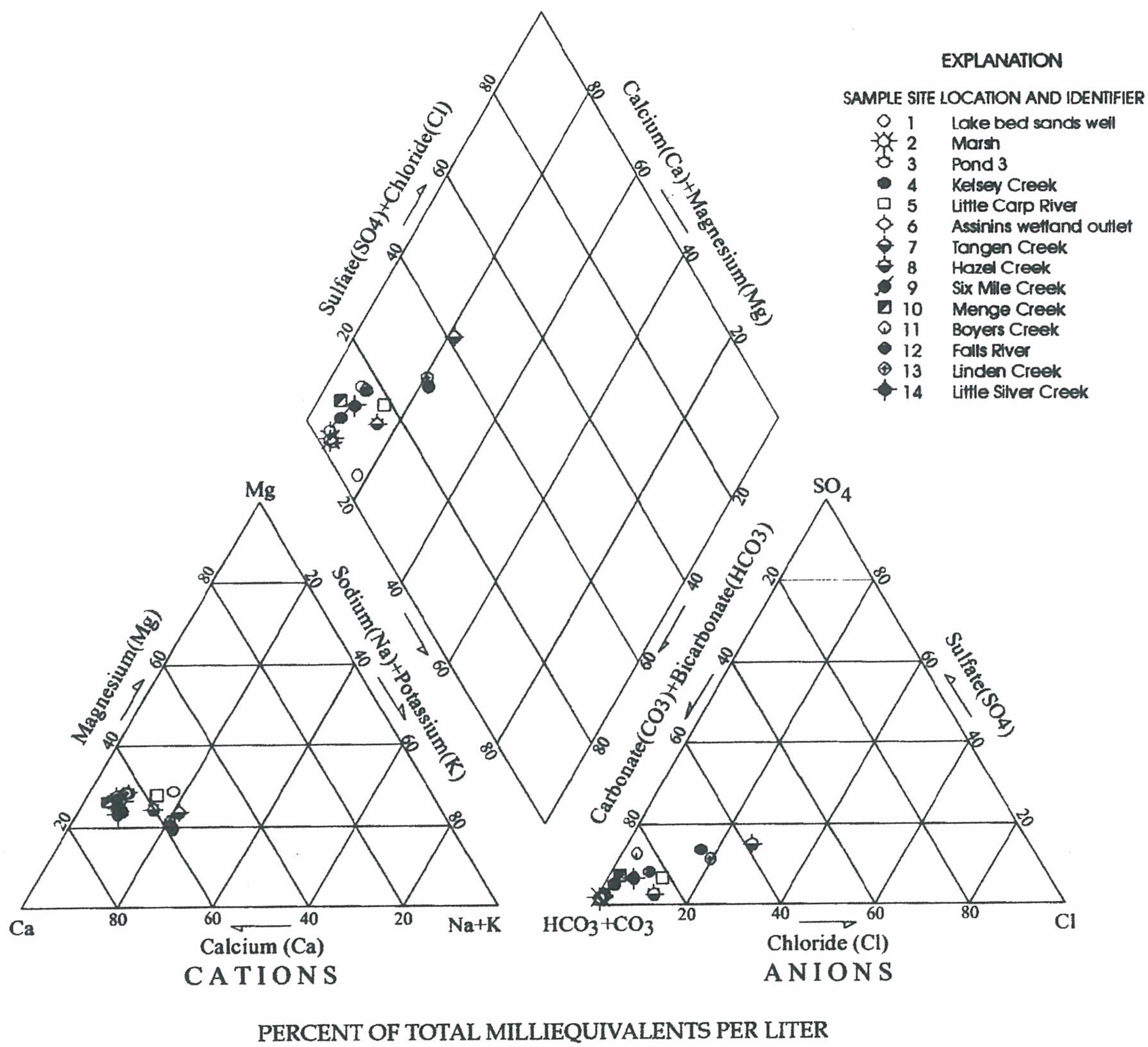

Figure 7. Trilinear diagram of surface-water, wetland open-water, and wetland well-water chemistry, Keweenaw Bay Indian Community (1991 data).

The geochemistry of water from the Jacobsville Sandstone and Michigamme Slate is more variable, and changes with location from west to east through the study area. In the western part of the study area, waters are typically of a sodium-chloride or calcium-chloride type, changing to a calcium-magnesium-bicarbonate type in the eastern part of the study area.

Ground-water flow in the study area is generally toward Keweenaw Bay, with local exceptions in the eastern part of the study area. Ground-water divides generally coincide with surface-water divides with only minor differences. In the eastern part of the study area, some ground-water flow is toward Huron Bay or Silver River. In general, ground-water flow is lateral, with an upward potential, as evidenced by flowing wells and water levels above land surface, particularly in low-lying areas near Keweenaw Bay, and along the lower slopes leading to the Bay.

The ages of ground water in KBIC, determined on the basis of concentrations of the radioactive isotope tritium, indicate that recharge to the Jacobsville Sandstone and Michigamme Slate has occurred in the last 45 years, particularly in areas where the aquifers are exposed at land surface or covered by a thin mantle (less than 5 m) of unconsolidated alluvium and glacial material. Recharge to the glacial aquifers likely occurs at the water table on an annual basis. Recharge is limited locally by the composition of the deposits, as indicated by tritium data in 2 wells indicating that recharge at the point of measurement in the glacial deposits takes more than 45 years.

Of principal concern to the Keweenaw Bay Indian Community is the susceptibility to contamination of aquifers down gradient (southeast) of the industrial park. Between 26 and 56 m of surficial material, most of which is clay or clay mixed with sand, overlies the bedrock in this area. Depth to water is between 26 and 63 m. Tritium concentrations in 2 wells down gradient from the industrial park indicate at least partial recharge to the Jacobsville Sandstone in the last 45 years. Surficial spills of contaminants in the area of the industrial park could possibly be confined to the upper layers of the surficial deposits. Steep slopes between the industrial park and Keweenaw Bay would tend to channel runoff over and through the shallow surficial deposits, toward Keweenaw Bay. However, at the industrial park, and downgradient of the industrial park, the Jacobsville Sandstone is unconfined. The industrial park is situated in an area where recharge is likely to occur to the Jacobsville Sandstone. Additional data are needed to develop a well-head protection plan for the industrial park and KBIC. Without additional data, it is not possible to make definitive statements about the safety of the water resource in the Jacobsville Sandstone, nor about it's potential for contamination from spills of contaminants on the land surface.

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GLOSSARY

Aquifer. A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Base flow. The discharge entering stream channels as inflow from ground water or other delayed sources; sustained or fair-weather flow of streams.

Bedrock. Consolidated rock that underlies soil or other unconsolidated material.

Concentration. The weight of a dissolved constituent or sediment per unit volume of water, expressed in milligrams per liter (mg/L) or micrograms per liter (mg/L).

Cubic meters per second. A unit expressing rate of discharge. One cubic meter per second is equal to the discharge of a stream 1 meter wide and 1 meter deep flowing at an average velocity of 1 meter per second.

Discharge. The rate of flow of a stream; reported in cubic meters per second (m^3/s).

Dissolved solids. Substances present in water that are in true chemical solution.

Divide. A line of separation between drainage systems. A topographic divide delineates the land from which a stream gathers it water; a ground-water divide is a line on a potentiometric or water-table surface, on each side of which the potentiometric surface slopes downward away from the line.

Elevation. Vertical distance of a point or line above or below the National Geodetic Vertical Datum of 1929 (NGVD of 1929). The NGVD of 1929 is a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929." In this report, all elevations are above NGVD of 1929.

Evapotranspiration. Water withdrawn from a land area by direct evaporation from water surfaces and moist soil, and by plant transpiration. No attempt is made to distinguish between the two.

Ground water. Water that is in the saturated zone from which wells, springs, and inflow to streams are supplied.

Ground-water runoff. Ground water that has discharged into stream channels by seepage from saturated earth materials.

Hydraulic conductivity. The volume of water at the prevailing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. In general terms, hydraulic conductivity is the ability of a porous medium to transmit water.

Isotropy. The condition of having properties that are uniform in all directions.

Permeability. A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient. It is a property of the medium alone, and is independent of the nature of the fluid and of the force field.

Potentiometric surface. An imaginary surface representing the total head of ground water and defined by the level to which water will rise in a well.

Recharge. The process by which water is infiltrated and is added to the zone of saturation. It is also the quantity of water added to the zone of saturation.

Runoff. That part of the precipitation that appears in the streams; the water draining from an area.

Storage coefficient. The volume of water released from storage in a vertical column of 1.0 square meter when the water table or other piezometric surface declines 1.0 meter.

Specific conductance. A measure of the ability of water to conduct an electric current, expressed in microsiemens per centimeter (mS/cm) at 25 degrees Celsius. Because the specific conductance is related to the amount and type of dissolved material, it is used for approximating the dissolved-solids concentration of water. For most natural waters, the ratio of dissolved-solids concentration (in milligrams per liter) to specific conductance (in microsiemens) is in the range 0.5 to 0.8.

Transmissivity. The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Water table. That surface in an unconfined water body at which the pressure is atmospheric. It is defined by levels at which water stands in wells. No water table exists where the upper surface of the water body is confined by low-permeability materials.

Type	Total present in study (out of 28 sites)
Submerged marsh (Aquatic)	15
Emergent marsh (reed canary grass)	7
Emergent marsh (cattail)	10
Emergent marsh (mix)	8
Wet meadow	18
Fen, shrub (leatherleaf, fen/bog)	4
Fen, shrub (mix)	4
Fen, sedge	3
Shrub thicket (alder dominant)	17
Shrub thicket (alder-willow mix)	8
Shrub thicket (willow dominant)	2
Conifer swamp forest (cedar)	11
Conifer swamp forest (tamarack)	6
Conifer swamp forest (conifer mix)	2
Hardwood swamp forest (black ash dominant or mixed with other hardwoods)	19
Hardwood-conifer swamp forest	10